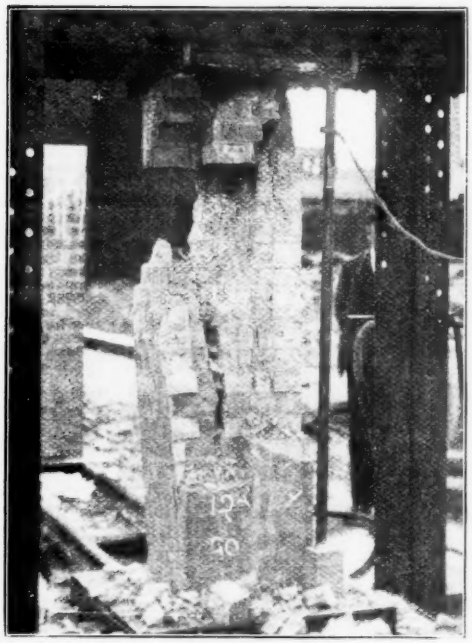

FIG. 1.—PIER 12A. AFTER 240 LB. ON GAUGE.

FIG. 2.—PIER 14A COLLAPSING.

BRICKWORK TESTS.

REPORT ON THE SECOND SERIES OF EXPERIMENTS, by WILLIAM C. STREET [*F.*] and MAX. CLARKE [*A.*]. With APPENDICES by Professor UNWIN [*H.A.*], F.R.S.

Read at the General Meeting, Monday, 14th December 1896, and, with the illustrations, registered at Stationers' Hall as the property of the Royal Institute.

WE have now, on behalf of the Science Standing Committee, to present our report on the second series of experiments on brickwork piers.* These took place on the same site as the first, at the West India Docks, during the month of June last.

It will be remembered that, owing to the very unsatisfactory manner in which some of the piers, the subject of experiment in December 1895, had been built, duplicates were determined upon, and these were the piers first tested in June. The piers were three months old, having been built in March, and were numbered 1*a*, 11*a*, 12*a*, 14*a*, 15*a*, and 16*a*, replacing the same numbers in the first series. After crushing these piers there remained the second eight in lime mortar, and the second eight in cement mortar, built at the same time as those the subject of the first series of experiments, and consequently ten months old when tested in June. When these had been crushed, a pier was built, at the suggestion of Professor Unwin, of bricks laid in sand, and experimented upon in the same way as the others.

The principal part in the experiments was undertaken by Messrs. William C. Street, Max. Clarke, Matt. Garbutt, and Bernard Dicksee, members of the sub-committee, who were present throughout the whole of the crushings. Mr. Street took note of and called the pressures; Mr. Clarke superintended the preparation of the photographs from which the illustrations have been selected and prepared; Mr. Garbutt, with the exception of a part

* The Report on the First Series of Experiments conducted by the Science Standing Committee, with Supplementary Papers by Professor Unwin, F.R.S., will be found in the JOURNAL, Vol. III. Third Series, pp. 333-358.

Pier No. 11*a*.—Gault Bricks from Burham, Kent, in Cement Mortar 1 to 4.

6′ 0⅞″ high ; 18″ × 18″ ; sectional area 2·25 sq. ft.
Built 11th March ; crushed 8th June. Age 12⅝ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
11.27	9	0·66	0·29	—	Took its bearing.
11.31	11	1·66	0·73	$\frac{2}{32}$	
11.34	20	6·14	2·72	$\frac{4}{32}$	
11.36½	40	16·10	7·15	$\frac{6}{32}$	
11.37	45	18·59	8·26	—	Small crack in brick, N.W. corner, top course.
11.38	50	21·08	9·36	$\frac{8}{32}$	
11.38½	55	23·57	10·47	—	Crack in brick, S.W. corner, bottom course.
11.45½	70	31·04	13·79	—	Crack in brick, N.E. corner, bottom course.
11.48½	80	36·02	16·00	—	Mortar falling out of bottom on E. face.
11.49½	85	38·51	17·11	—	Crack in bottom course, N.E. corner, beginning to open.
11.52	95	43·49	19·32	—	Brick at S.E. corner, bottom course, bursting.
11.55½	110	50·96	22·64	—	Bottom course crushing, and mortar falling from joints.
11.56½	125	58·43	25·97	—	Bottom course crushing, audible cracks.
11.57	135	63·41	28·18	—	Cracking slightly on E. face, tenth course from bottom.
11.58	150	70·88	31·50	—	Bricks spalling, two courses from bottom, W. face.
11.59	160	75·86	33·71	$\frac{9}{32}$	Crushing badly, two courses from bottom, W. face; the pressure fell 3 lb., but the pier generally intact.
12.2	165	78·35	34·82	—	The crushing at bottom extended to three courses.
12.4	170	80·84	35·92	—	The crushing at bottom extended to four courses through stretcher in line of closers.
12.7	175	83·33	37·03	$\frac{10}{32}$	Second course from top, N.E. corner, spalling.
12.9½	180	85·82	38·14	—	Second course from top, N.W. corner, brick cracking.
12.12½	185	88·31	39·24	$\frac{11}{32}$	Slight fall of pressure.
12.16	195	93·29	41·46	—	Compression again $\frac{11}{32}$.
12.19½	220	105·74	46·99	$\frac{13}{32}$	Crushing well at bottom seven courses, N.E. angle, and face of two bottom courses on W. face falling off. Slight but steady falling of mortar.
12.24	225	108·23	48·10	$\frac{14}{32}$	Pier suddenly burst out at bottom and fell. The top six courses remained and fell intact. The next eight courses split into four equal portions ; beneath this a few courses were crushed completely, while at bottom a pyramid about five courses high remained on head of ram. The cement was set and hard all through, the joints being well flushed up.

Pier No. 12*a*.—Gault Bricks from Burham, Kent, in Cement Mortar 1 to 4.

6′ 0¼″ high ; 18″ × 18⅛″ ; sectional area 2·266 sq. ft.
Built 12th March ; crushed 8th June. Age 12⅛ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
2.21	12	2·15	0·94	—	Took its bearing.
2.24½	70	31·04	13·69	$\frac{5}{32}$	Slight internal sounds, not cracks.
2.28	105	48·47	21·39	$\frac{6}{32}$	Crack in top three courses, N.W. corner, ¾″ from angle. Crack in top three courses, S.W. course, 1¼″ from angle.
2.30	115	53·45	23·58	—	Crack two courses down, centre of W. face.
2.33½	130	60·92	26·88	$\frac{7}{32}$	Another crack, S.W. corner, through two top courses, and 4½″ from angle.
2.36½	155	73·37	32·37	$\frac{8}{32}$	Cracks previously noted in top courses extending.
2.39½	180	85·82	37·87	$\frac{9}{32}$	Top courses getting worse.
2.40	185	88·31	38·97	—	Western closer on ninth course, N. face, spalling.
2.42	195	93·29	41·16	—	Crack at top N.W. corner extending and spalling.
2.45½	210	100·76	44·46	$\frac{10}{32}$	Pieces bulging and falling, N.W. top corner.
2.50	230	110·72	48·86	$\frac{11}{32}$	Cracking up all over.
2.51	240	115·70	51·05	$\frac{12}{32}$	Split suddenly and failed completely. Cracking from top downward, following the line of closers. (See fig. 1, p. 73.) The pier well built ; cement set and hard; no joints squeezed out until the final crushing.

when Mr. Burrows was present, recorded the compression of the piers at the different pressures, and took notes on one side of the testing apparatus; while Mr. Dicksee called the time, and made notes on the other side of the apparatus. The valve by which the pressure water was admitted into the press was regulated by Mr. Creighton, the foreman at the Docks.

The compression observations were made with a gauge constructed specially for this purpose by Mr. Adie, and, except in one instance (Pier No. 26), when there was an accident in setting the instrument, the observations were satisfactorily and easily made.

On the 15th June the effective pressures of the testing machine were again ascertained by Professor Unwin in the manner set forth in one of the Appendices to this Report, and it is upon the formula derived therefrom by Professor Unwin that the pressures in the tabular results have been calculated.

Pier No. 14*a*.—Leicester Red Bricks from Ellistown, near Leicester, in Cement Mortar 1 to 4.

6′ 0½″ high; 18″ × 18″; sectional area 2·25 sq. ft.
Built 13th March; crushed 8th June. Age 12⅔ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
3.22	13	2·65	1·17	—	Took its bearing.
3.23½	30	11·12	4·94	3/32	
3.24½	45	18·59	8·26	4/32	
3.25½	60	26·06	11·58	5/32	
3.27	85	38·51	17·11	6/32	
3.30	125	58·43	25·97	7/32	Until this pressure was called the pier showed no signs of strain.
3.34	140	65·90	29·28	—	S. side, 7½″ from W. corner; slight crack two top courses.
3.36½	150	70·88	31·50	—	Crack in N.E. top-corner brick; face split off 2″ × 3″. S. side 1″ from W. corner; two top courses slightly cracked.
3.40	160	75·86	33·71	8/32	Crack top of E. face, in centre joint.
3.41	170	80·84	35·92	—	S. side, at W. corner, top course, slight spall.
3.42	175	83·33	37·03	—	W. face, two top courses slightly giving at S. corner.
3.44	185	88·31	39·24	—	E. face, top crack extending down two courses at closer.
3.44½	195	93·29	41·46	9/32	
3.46½	210	100·76	44·78	—	N.E. top brick crushing at end (N. face).
3.48	220	105·74	47·00	—	S. side, bottom course; very thin flakes off face.
3.50	225	108·23	48·10	—	Bottom two joints slightly spalling off.
3.51½	230	110·72	49·20	—	S. side, third course from bottom; slight flaking of face.
3.54½	245	118·19	52·52	10/32	
3.56	255	123·17	54·74	—	S.W. top corner, surface crushed, but hardly any fallen out.
3.57	260	125·66	55·84	—	S. side, third course from bottom, spalled and split at 4½″ from S.E. angle. N.W. bottom corner cracking and spalling off two courses up.
3.59	275	133·13	59·16	—	S. side, second joint from bottom, burst out and fell off for length of 9″.
4.0½	300	145·58	64·70	11/32	S. side still sound, all but three top and three bottom courses.
4.1½	315	153·05	68·02	—	S.W. angle, second bed-joint from top; mortar dropping slightly but steadily.
4.3½	330	160·52	71·34	—	S. side, at S.E. angle; bottom three courses cracked.
4.4	340	165·50	73·55	12/32	
4.4½	350	170·48	75·76	—	S. side, 7½″ from S.W. angle; crack down through top courses.
4.5	360	175·46	77·98	—	Sharp sound of cracking. Crack four courses down from top at N.E. corner. Bottom two courses crushing on N. face.
4.6	375	182·93	81·30	—	S. side, 7½″ from S.E. angle; crack from top down through six courses.
4.6¼	380	185·42	82·40	—	Cracked down nine courses in several places on N. face.
4.7	385	187·91	83·51	—	S. side, 4½″ from S.E. angle; cracks from fifth to eighth course from top. N. side, cracks extended down twelve courses at both closers.
4·8	390	190·40	84·62	—	Cracking at middle of pier on S. and E. faces. joint and bricks spalling.
4.9½	395	192·89	85·72	—	More cracks showing vertically, mostly near top, and at closer lines.
4.9½	398	194·38	86·39	—	Pier collapsed, bursting out on all sides. (See fig. 2, p. 73.) Pier well built. Cement set and hard.

The tables annexed to this Report, giving the results of each experiment, have been prepared by Mr. Street from the collective observations of the sub-committee.

Pier No. 15*a*.—Staffordshire Blue Bricks from Rowley Regis, in Cement Mortar 1 to 4.

6′ 0$\frac{3}{8}$″ high; 18$\frac{1}{2}$″ × 18″; sectional area 2·266 sq. ft.
Built 14th March; crushed 10th June. Age 12$\frac{1}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
10.54	11	1·66	0·73	—	Took its bearing.
10.55	40	16·10	7·10	$\frac{1}{32}$	
10.55$\frac{1}{2}$	50	21·08	9·30	$\frac{2}{32}$	
10.56$\frac{1}{2}$	120	55·94	24·68	$\frac{3}{32}$	
—	140	65·90	29·08	$\frac{4}{32}$	
—	155	73·37	32·37	—	Sharp internal crack heard.
10.57	160	75·86	33·47	$\frac{4}{32}$	
—	164	77·85	34·35	—	Second sharp internal crack heard.
11.4$\frac{1}{2}$	200	95·78	42·26	—	Distinct crack, pier jumped or jerked slightly, and there was a small fall of pressure.
11.6	210	100·76	44·46	$\frac{5}{32}$	
—	215	103·25	45·56	—	N. face, 4$\frac{1}{2}$″ from N.E. angle; crack down through three top courses.
11.8	235	113·21	49·96	—	Bottom joint on S. face spalling; also on three courses from top on N. face.
11.8$\frac{1}{2}$	240	115·70	51·05	$\frac{6}{32}$	
11.10	250	120·68	53·25	—	Brick cracked and spalling on fourth course from top N.E. angle.
11.11	256	123·66	54·57	—	Crack up four courses, S.E. bottom corner at closers.
—	258	124·66	55·01	—	Crack up four courses, extended upwards five courses.
11.13$\frac{1}{2}$	270	130·64	57·65	—	Crack up four courses, extended upwards seven courses.
11.16	290	140·60	62·04	$\frac{7}{32}$	Audible sharp crack, pressure gauge jumped up 3 lb. with jerk.
11.17$\frac{1}{2}$	300	145·58	64·24	—	N. side, 4$\frac{1}{2}$″ from N.E. corner; crack through bottom seven courses. N. side, 7$\frac{1}{2}$″ from N.E. corner, fourth course from top; vertical crack in one brick only.
11.19	310	150·56	66·44	—	E. face, slight spalling of joints.
11.22$\frac{1}{2}$	330	160·52	70·83	—	Loud sharp crack, slight dropping of cement. Crack through one brick in seventh course, N. side, 4$\frac{1}{2}$″ from N.E. angle. Crack at top S.E. corner extending from third to eighth course at closer, S. face.
11.23	335	163·01	71·53	$\frac{8}{32}$	Crack S.E. corner extended to top, and crack N.E. corner extending down through eight courses.
11.24$\frac{1}{2}$	380	185·42	81·86	—	S. face, top crack opening very slightly, and extended down ten courses; closers. E. face, slight spalls third to fifth course from top; cracks nearly in centre of face. N. face, 4$\frac{1}{2}$″ from N.E. angle; crack through ten top courses. N. face, 4$\frac{1}{2}$″ from N.E. angle; brick in second course spalling.
—	385	187·91	82·96	$\frac{9}{32}$	
11.32	390	190·40	84·06	—	Bottom crack, S. face, extended eight courses up. N. side, 4$\frac{1}{2}$″ from N.E. corner; split twelve courses down from top. E. side, joints crushing and surface spalls.
11.33	400	195·38	86·26	—	E. side, cracks down centre to tenth course. Sharp crack heard, and fall of pressure.
11.36	410	200·36	88·46	—	S. face, top crack open $\frac{1}{16}$.
11.37	420	205·34	90·66	$\frac{10}{32}$	Cement falling from two bottom courses, audible cracking. Another crack on S. face, centre of height and width, through three courses.
11.40	430	210·32	92·85	—	Top crack at S.E. angle extended twelve courses down. N. side, 4$\frac{1}{2}$″ from N.E. corner; split thirteen courses down.
11.42	470	230·24	101·65	—	Pressure fell, then rose again.
—	480	235·22	103·85	$\frac{11}{32}$	Crack last mentioned suddenly extended to bottom of pier, and pressure fell.
11.45	490	240·20	106·05	$\frac{12}{32}$	Many splits.
11.46	500	245·18	108·25	—	Pier gave way, and, after crushing, a core 9″ × 9″, and about ten courses high, remained firmly held together. (See figs. 3 and 4.)

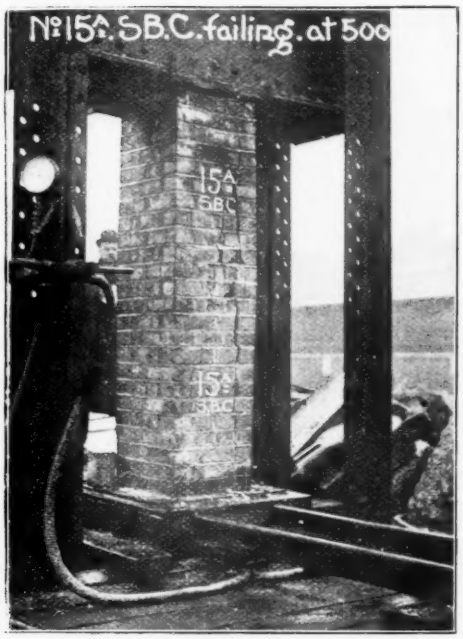

FIG. 3.—PIER 15*a* FAILING. GAUGE AT 500.

FIG. 4.—PIER 15*a* IN ACT OF FALLING.

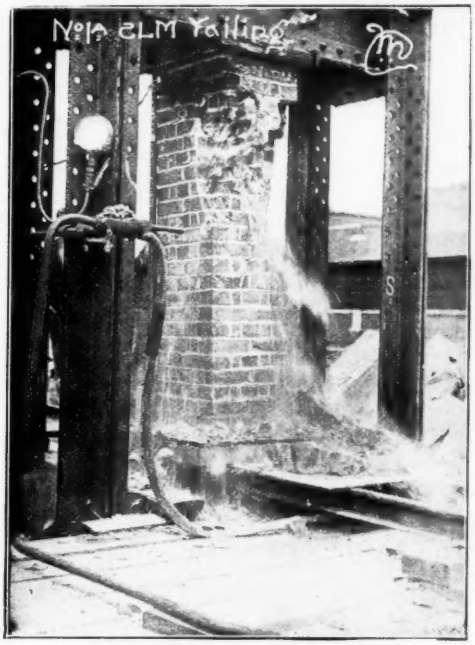

FIG. 5.—PIER 1*a* FAILING. GAUGE AT 92.

FIG. 6.—PIER 17, SHOWING MODE OF FAILURE.

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Pier No. 16*a*, Staffordshire Blue Bricks from Rowley Regis, in Cement Mortar 1 to 4.

6′ 0¼″ high; 18″ × 18″; sectional area 2·25 sq. ft.
Built 14th March; crushed 12th June. Age 12⅝ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes.
10.37	12	2·15	·95	—	In bearing.
10.38½	20	6·14	2·72	1/32	
10.40	30	11·12	4·94	3/32	
10.41	40	16·10	7·15	3/32	
10.42	70	31·04	13·79	5/32	
10.43	130	60·92	27·07	5/32	
10.44	170	80·84	35·92	5/32	Commenced to flake and crack near top.
10.49	220	105·74	46·99	—	Farther cracks in top, and gauge fell.
10.56	250	120·68	53·63	6/32	
10.56½	280	135·62	60·28	—	Cement squeezing out of third bed from top.
10.57½	300	145·58	64·60	—	Crack six courses down S.W. corner; sixth course only scaled.
11.2½	350	170·48	75·76	9/32	
11.4	370	180·44	80·19	—	Top five or six courses well cracked.
11.8	400	195·38	86·83	10/32	Spalling at joints two courses from bottom.
11.10	410	200·36	89·04	—	Cracks opening.
11.17½	420	205·34	91·26	—	Crack at S.E. corner of top extended down ten courses.
11.31	440	215·30	95·69	—	Pier bulging and spalling. Gauge fell to 410.
11.32	450	220·28	97·90	11/32	Pier cracking and opening, and gauge fell to 395, then rose again to 430, when pier burst, the bottom seven to ten courses remaining practically sound.
11.36	430	210·32	93·47	—	

Pier No. 1*a*.—Stock Bricks from Sittingbourne, in Lime Mortar 1 to 2.

5′ 10⅜″ high; 18⅛″ × 18⅛″; sectional area 2·297 sq. ft.
Built 14th March; crushed 12th June. Age 12⅝ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes.
12.18	12	2·15	·94	—	In bearing.
12.21	20	6·14	2·67	2/32	
12.27	40	16·10	7·01	—	Cracks in top course at N.E. and S.W. corners.
12.28	45	18·59	8·09	5/32	Cracking in top two courses.
12.30	55	23·57	10·26	6/32	
12.32	65	28·55	12·43	—	Cracks extending down four courses, and mortar falling.
12.36½	85	38·51	16·76	—	Cracks extending down six courses. Internal cracks heard.
12.38	90	41·00	17·84	12/32	Cracks extending and compression continuing without increase of pressure.
12.39½	92	41·99	18·28	13/32	New cracks suddenly developed and pier fell. The bottom nine courses tolerably sound; mortar on N. face softer than that on the S. (See fig. 5, p. 77.)

Pier No. 17.—Stock Bricks from Sittingbourne, in Lime Mortar 1 to 2.

6′ 0⅛″ high, 18 3/16″ × 18¼″; sectional area 2·305 sq. ft.
Built 12th August 1895; crushed 12th June 1896. Age 43¾ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
2.8	15	3·65	1·58	—	In bearing.
2.11¼	35	13·61	5·90	2/32	
2.12½	45	18·59	8·06	3/32	Internal crack audible.
2.13	50	21·08	9·14	4/32	Crack top S.W. corner, two courses down, below defective vertical joint.
2.13½	55	23·57	10·22	5/32	
2.14	60	26·06	11·30	6/32	N. side 4½″ from N.E. angle cracked from third to seventh course inclusive.
2·15	70	31·04	13·46	—	Pier split in centre from top to bottom.
	73	32·53	14·11	12/32	Compression continuing and pier fell. (See fig. 6, p. 77.)

*** Mortar set, but apparently badly mixed.

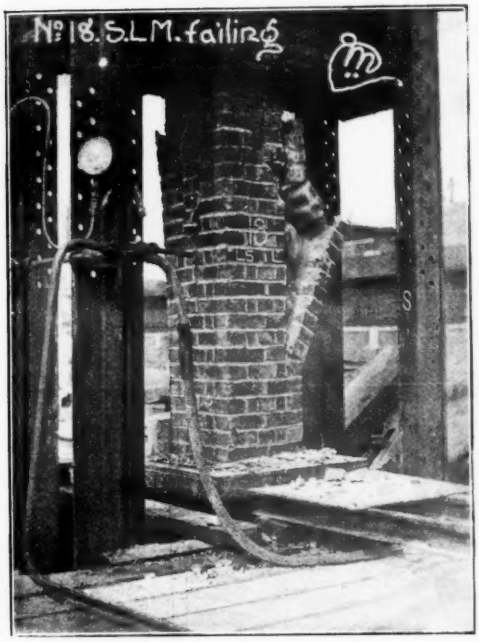

FIG. 7.—PIER 18 FAILING. GAUGE AT 59.

FIG. 8.—PIER 19, AFTER FAILURE. GAUGE 51·95.

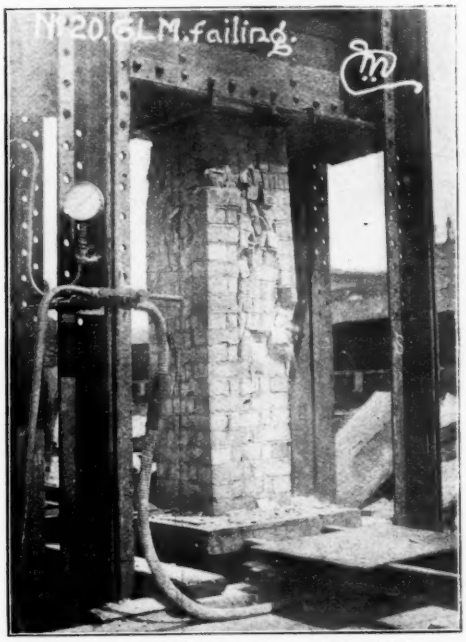

FIG. 9.—PIER 20. COMMENCEMENT OF COLLAPSE.

FIG. 10.—PIER 20 COLLAPSING.

Pier No. 18.—Stock Bricks from Sittingbourne, in Lime Mortar 1 to 2.

6′ 0⅜″ high; 18⅜″ × 18¼″; sectional area 2·329 sq. ft.
Built 12th August 1895; crushed 12th June 1896. Age 43⅛ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
2.43	11	1·66	·71		In bearing.
2·44	15	3·65	1·56	1/32	
2.44½	20	6·14	2·63	2/32	
2.45	23	7·63	3·27	3/32	
2.46	27	9·62	4·13	4/32	
2.47	35	13·61	5·84	5/32	Cracks in first and second courses at lines of closers.
2.48⅓	40	16·10	6·91	6/32	Crack centre of W. face, top course.
2.50	45	18·59	7·98		N.E. and S.W. corners, cracking down two courses.
	48	20·08	8·62	7/32	
2.51	50	21·08	9·05		Cracks extending down ten courses, and mortar dropping.
	53	22·57	9·69	8/32	
2.53	55	23·57	10·12		Cracks extending and bricks spalling.
	57	24·56	10·54	9/32	
	58	25·06	10·76	10/32	
3.1	59	25·56	10·97	11/32	Compression continued to 14/32 at same pressure and then the pier fell. (See fig. 7, p. 79.)

Pier No. 19.—Gault Bricks from Burham, Kent, in Lime Mortar 1 to 2.

6′ 0½″ high; 18⅛″ × 18″; sectional area 2·266 sq. ft.
Built 12th August 1895; crushed 12th June 1896. Age 43⅛ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
3.33½	10	1·16	·52		In bearing.
—	12	2·15	·95	3/32	
3.34½	15	3·65	1·61	5/32	
—	18	5·14	2·27	6/32	
3.35½	19	5·64	2·49	7/32	
—	23	7·63	3·36	8/32	
3.36½	26	9·12	4·02	9/32	
3.37½	30	11·12	4·94	10/32	
	37	14·60	6·44	11/32	Internal cracks heard.
3.41	43	17·59	7·76	12/32	
—	47	19·58	8·64	13/32	
3.42½	50	21·08	9·30	—	E. side, fifth course from top, 7½″ from N.E. angle, crack.
3.44½	55	23·57	9·96	14/32	N. face, cracking in sixth, seventh, and eighth courses in line of closers.
—	61	26·55	11·71	15/32	
3.52	70	31·04	13·69	16/32	S. face, crack in eighth course at inner line of closers. N. face, crack down through tenth course about 5½″ from N.E. angle.
3.55	75	33·53	14·79	17/32	
3.58	80	36·02	15·89	18/32	S. face, crack extending downwards through twelfth course. N. face 4½″ from N.W. corner, split from top to eighth course, mortar falling. N face, 4½″ from N.E. corner, crack through fourteenth, fifteenth, and sixteenth courses.
4.1¾	85	38·51	16·99	19/32	Crack in S.E. bottom angle two courses up. Spalling on E. face and mortar dropping on N. face.
4.4½	90	41·00	18·09	20/32	Pier cracking and spalling, mortar dropping.
4.6	93	42·49	18·75	21/32	Crack on S. face opening slightly.
4.8	97	44·48	19·63	22/32	Cracking up in several places on W. side, centre of height, joints crushing out generally.
—	99	45·48	20·07	23/32	
4.11	100	45·98	20·29	—	Crack in S.E. ang'e extending.
4.13¼	103	47·47	20·94	24/32	Cracks extending on W. side up and down from centre at both closers, joints near bottom crushing.
4.15	105	48·47	21·39	25/32	Cracks opening generally and bricks spalling.
4.17½	110	50·96	22·49	26/32	Gauge fell to 108, the spalling of bricks and dropping of mortar continuing steadily.
—	112	51·95	22·93	27/32	
4.21½	112	51·95	22·93	28/32	Bulged at six courses from top, a few bricks fell, momentary pause, and then collapse. Two pyramids were clearly formed. (See fig. 8, p. 79.)

FIG. 11.—PIER 21 COLLAPSING.

FIG. 12.—PIER 22 COLLAPSING.

FIG. 13. PIER 24 COLLAPSING.

FIG. 14.—PIER 25 COLLAPSING.

As has already been stated in the JOURNAL, the Committee are proceeding with a third series of experiments—namely, upon short lengths of wall built without closers, and of a more perfect bond than can be obtained with piers 18 inches square. The piers generally failed at the line of closers, while at the best the bond allowed a small continuous vertical joint in each of the angles. The work of cutting closers in hard bricks is so difficult that the workmen, when building some of the first lot of piers, committed the sin of inserting closers of soft bricks instead while the members of the Committee were absent. The lengths of wall now waiting the period of crushing have been carefully watched during building, and, whatever the results may be, there is little fear of their being prejudiced by bad workmanship.

When these further experiments are complete, the Committee will be in a position to make another and final report upon the whole series, and expect to be able to establish from the data derived from the experiments definite rules as to the safe loads for the various kinds of brickwork with which they have been dealing.

Meanwhile, it is interesting to note the great difference between the strength of bricks and of brickwork, the enormous disproportion being due to the quality of the material interwoven with the bricks as a means of uniting and holding the mass together. The effect

Pier No. 20.—Gault Bricks from Burham, Kent, in Lime Mortar 1 to 2.

6′ 0½″ high; 17⅞″ × 17¼″; sectional area 2·219 sq. ft.
Built 10th August 1895; crushed 15th June 1896. Age 44⅞ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
10.34	10	1·16	·52	—	In bearing.
10.37½	11	1·66	·75	3/32	
—	14	3·15	1·42	5/32	
10.40	15	3·65	1·65	5/32	
—	19	5·64	2·54	7/32	
—	23	7·63	3·44	7/32	
10.41½	25	8·63	3·89	9/32	
—	33	12·61	5·68	11/32	
10.43	40	16·10	7·25	13/32	
10.43½	45	18·59	8·38	11/32	
10.44	50	21·08	9·50	—	Crack through stretcher at top, E. corner of S. face.
—	53	22·57	10·17	12/32	
10.45	55	23·57	10·62	—	Crack extended three courses down at line of closers; crack in seventh course down centre of S. face.
10.46½	60	26·06	11·74	—	Crack in top course, west corner of S. face.
—	61	26·55	11·97	13/32	Cracks in corners of top course on N. and W. faces.
10.48	65	28·55	12·86	—	Crack in eighth course through stretcher at E. corner of N. face.
10.49	70	31·04	13·99	14/32	Bed of sixth course N. face slightly squeezed out.
10.50	75	33·53	15·11	—	Audible internal crack, mortar falling, and slight spalling.
—	78	35·02	15·78	15/32	
10.53	80	36·02	16·23	—	Cracking downwards at lines of closers on N.W. and S. faces.
—	84	38·01	17·13	15/32	
10.55	85	38·51	17·35	—	Bricks spalling and cracking from top down to fourteenth course, and also crack on E. side in second course from bottom.
—	88	40·00	18·03	17/32	Pier specially distressed at S. corner of E. side near centre.
11.3	89	40·50	18·25	18/32	Pressure falling.
11.9	90	41·00	18·48	—	Pressure rising again.
11.10	95	43·49	19·60	19/32	Mortar dropping and joints opening.
—	98	44·98	20·27	20/32	Brick faces bursting out on E. side and pressure falling.
—	96	43·98	19·82	20/32	Pressure still falling.
11.12	80	36·02	16·23	20/32	Compressing rapidly and cracks opening. (See fig. 9, p. 79.)
11.15	—	—	—	—	Pier bulged out and fell. (See fig. 9, p. 79.)

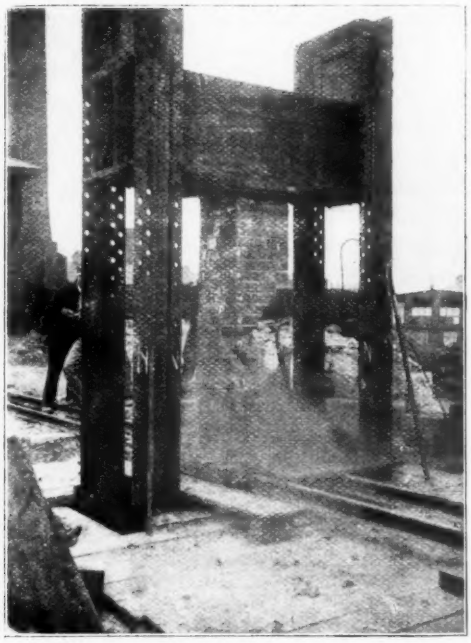

FIG. 15.—PIER 26 COLLAPSING.

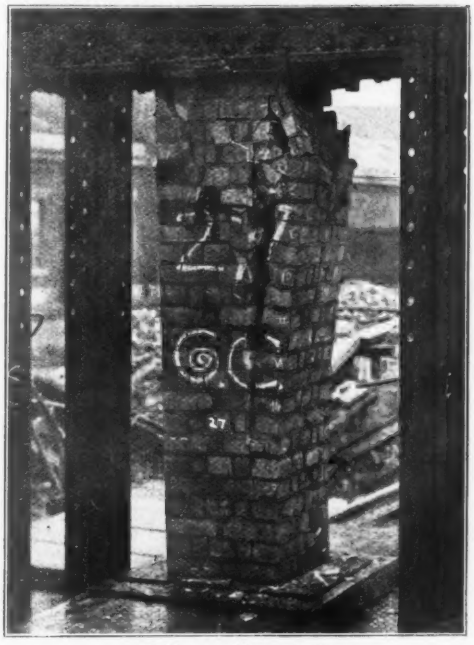

FIG. 16.—PIER 27 COLLAPSING.

FIG. 17.—PIER 28 COLLAPSING.

FIG. 18.—PIER 31 COLLAPSING.

upon different kinds of bricks is variable, owing to some bricks being more susceptible to adhesion than others. Again, if the mortar be imperfectly mixed, or the joints and beds of the brickwork imperfectly filled up, the injurious effect on strength is incalculable. It introduces unequal pressures in different parts of the body, and the work fails in detail until so much of the whole is destroyed that the remainder suddenly collapses. It is dull work trying to hammer-in the obvious, yet too much stress cannot be laid upon the care required in the selection, preparation, and application of mortar.

The diagrams [pp. 94, 95] showing the compression of the piers under the several pressures constitute a graphic representation of the gradual destruction of the mortar and brick-

Pier No. 21.—Red Bricks from Ellistown, near Leicester, in Lime Mortar 1 to 2.

6′ 0⅛″ high; 18⅛″ × 18⅛″; sectional area 2·281 sq. ft.
Built 13th August 1895; crushed 15th June 1896. Age 43⅝ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
11.45	10	1·16	·51	—	In bearing.
—	12	2·15	·94		
—	15	3·65	1·60		
—	19	5·64	2·47		
—	24	8·13	3·56		
11.49	30	11·12	4·87		Mortar squeezing from top two joints, front crack existing before pressure applied.
11.50	40	16·10	7·06		
—	50	21·08	9·24		
11.51½	60	26·06	11·43		
—	72	32·03	14·04		
11.54½	78	35·02	15·35	—	Audible crack.
11.56½	80	36·02	15·79		
11.59	85	38·51	16·88	—	Spalling at eighth course from top on E. side.
—	88	40·00	17·53		
12.6¾	100	45·98	20·16		
12.9	110	50·96	22·34	—	Cracks from sixteenth to twenty-first course from top on E. and S. sides.
12.10	115	53·45	23·44		Crack six courses down S.E. corner on both faces. Cracking at bottom on S.W. corner three courses up on both faces. Spalling at seventeenth course from top E. face.
12.11	120	55·94	24·52		Audibly cracking. E. and S. sides, five courses from bottom, cracked through at 4½″ from N.E. and S.W. angles, and the fifth course from bottom cracked at centre.
12.12	125	58·43	25·62		S.E. top crack extended ten courses down at line of closers.
12.14	130	60·92	26·71	—	
—	133	62·41	27·36		
—	137	64·40	28·23		Cracking on E. face diagonally from N.E. corner at bottom up to ninth course, from closer to closer.
12.16½	140	65·90	28·89		Pier well damaged on all sides for about six courses from top.
12.19½	145	68·39	29·98		N. side, face of eighth course from top burst off close to N.E. corner.
12.20	150	70·88	31·07	—	Cracking and spalling all over.
12.21	155	73·37	32·16		E. face crippled for ten courses from bottom.
12.22½	160	75·86	33·26		Crushing well on S. face S.E. angle, sixth to tenth course up from bottom; pier 18½″ wide here.
12.24	163	77·35	33·91		Pieces falling at bulge.
12.24	165	78·35	34·35	—	Failing generally.
—	166	78·84	34·35		Gauge began to fall.
12.25½	164	77·85	34·13		
—	162	76·85	33·69		
—	160	75·86	33·25		
12·28	151	71·37	31·29		Bulged out all round and fell. Two pyramids clearly formed and a cone about seven courses high left after the fall. (See fig. 11, p. 81.)

*** The mortar was set, but not very hard or well mixed.

work. It will be readily appreciated that when a pier or wall is failing in detail, cross and tensile strains are occasioned locally that attack irresistibly the remaining strength. This is well demonstrated in the instances of the piers which have failed by bending and shearing.

There is, however, one comforting reflection, namely, that if a building is likely to collapse from want of strength, it is more likely to do so while the mortar is fresh and green than at a later date; that is to say, if the mortar once gets set and matured under its load, the building will live its life, a longer or a shorter one according to the character of the building—or, shall one say, of the builders? A few weeks ago, in taking down some buildings less than a hundred years old, the bricks could be lifted piecemeal by the hand, and an overturn of three or four feet of wall was sure to dislocate the whole of the bricks. On the other hand, in some buildings several centuries old the mortar-joints are hard as iron, the joints

Pier No. 22.—Red Bricks from Ellistown, near Leicester, in Lime Mortar 1 to 2.

6′ 0¼″ high; 18¼″ × 18⅛″; sectional area 2·297 sq. ft.
Built 13th August 1895; crushed 15th June 1896. Age 43⅘ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
2.5½	10	1·16	·50	—	In bearing.
2.7½	20	6·14	2·67	1/32	
—	27	9·62	4·19	2/32	
2.9½	35	13·61	5·93	3/32	Mortar squeezing out at frost crack.
2.10½	50	21·08	9·18	4/32	Audible internal crack.
2.11	60	26·06	11·34	5/32	Crack top S.W. angle, third course down W. face.
—	78	35·02	15·24	6/32	Beginning to spall second course down S.W. corner, W. face.
2.13	85	38·51	16·74	7/32	E. side, top brick next N.E. corner, bad crack ½″ from corner. W. side, sixth course, face of brick coming off.
2.14	90	41·00	17·84	8/32	S.W. top crack W. face extended into fourth course down. Crack in N.W. bottom corner, W. face, up four courses. Crack S.E. corner, S. face in fourth course from top. Cracks in top courses on N. and E. faces. Crack in fourth course from bottom on E. face 6½″ from S.E. corner.
—	95	43·49	18·93	9/32	
—	107	49·46	21·53	10/32	
2.21	110	50·96	22·18	11/32	N. side, third course from top, flake.
2.24	120	55·94	24·35	12/32	Mortar dropping and bricks scaling.
	125	58·43	25·44	13/32	Cracks up six courses centre of S. face, and in fifth course from bottom on N. side, 5½″ from N.W. corner.
2.28	129	60·42	26·30	14/32	E. side, top course, spall ½″ thick off brick at N.E. corner. Crack eight courses down on W. face at S. closer.
—	134	62·91	27·38	15/32	Mortar squeezing out of joints, and cracks opening.
2.35	136	63·90	27·81	16/32	E. and N. sides, spalls on angle, and crack on N. face, continuing down through sixth course, 6½″ from N.E. corner. W. face, crack in sixth course down centre.
—	148	69·88	30·42	17/32	E. side, 4½″ from N.E. angle, split down to seventh course from top; N. side, sixth course, next N.W. angle, spall 7″ long off lower edge.
2.43	152	71·87	31·28	18/32	Crushing at S.E. bottom angle, third to seventh courses up.
2.44	153	72·37	31·50	19/32	Gauge fell a little and then recovered.
2.46	160	75·86	33·02		
—	164	77·85	33·89		Cracks on E. face opening.
—	157	74·36	32·37		Pressure falling fast.
—	152	71·87	31·28	20/32 and continuing	
—	150	70·88	30·85		Chief cracks extending and many fine cracks developing.
2.50	130	60·92	26·51		
2.51	110	50·96	22·18		Pier fell, having failed slowly and steadily, and leaving a well-marked core about seven courses high. (See fig. 12, p. 81.)

*** Mortar set, but not very hard.

protruding beyond the masonry, the surface of which had fretted away by the action of the atmosphere during the ages elapsed since the structure was built.

The diagram [p. 95] representing the last experiment—that upon a brickwork pier built in sand—gives a good idea of the way in which brickwork would fail if exposed to fresh or additional loads after the mortar had perished and become thoroughly disintegrated.

Pier No. 23.—Blue Bricks from Rowley Regis, in Lime Mortar 1 to 2.

6′ 0″ high; 18$\frac{3}{8}$″ × 18″; sectional area 2·297 sq. ft.
Built 13th August 1895; crushed 15th June 1896. Age 43$\frac{6}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
4.30	10	1·16	·50	—	In bearing.
4.32	20	6·14	2·67	$\frac{1}{16}$	
—	50	21·08	9·18	$\frac{3}{16}$	
—	70	31·04	14·11	$\frac{5}{16}$	
4.34	80	36·02	15·86	—	Top two courses cracked S. face.
4.3	85	38·51	16·74	$\frac{7}{16}$	Slight fall of mortar from joint faces.
4.34$\frac{1}{2}$	100	45·98	20·01	$\frac{9}{16}$	Crack five courses down S.E. angle, S. face, at closer.
5	110	50·96	22·18	$\frac{5}{8}$	Crack in fifth course down, E. face.
4.3	120	55·94	24·35	$\frac{11}{16}$	
4.36	130	60·92	26·51	$\frac{3}{4}$	E. side top course, 1″ from N.E. angle, vertical crack.
7	140	65·90	28·68	$\frac{13}{16}$	N. side, sixth bed, half face split off.
					Crack on S.E. corner, S. face, extended seven courses down.
4.37$\frac{1}{2}$	150	70·88	30·85	$\frac{7}{8}$	Mortar steadily giving.
4.38	160	75·86	33·02	$\frac{15}{16}$	Pier cracking in several places slightly.
4.39	170	80·84	35·19	1	
—	175	83·33	36·27	1$\frac{1}{16}$	Crack bottom, S. face, three courses up in centre.
4.42	182	86·81	37·79	1$\frac{1}{8}$	Faces of joints dropping off all over. E. face, eighth course down, closer nearest to N.E. angle spalled.
4.46	200	95·78	41·69	1$\frac{3}{16}$	
4.47$\frac{1}{2}$	210	100·76	43·86	1$\frac{1}{4}$	Bottom S. crack extended five courses up following joints.
4.49	220	105·74	46·03	1$\frac{5}{16}$	
—	228	109·72	47·76	1$\frac{3}{8}$	
4.50	230	110·72	48·19		E. side, fourth to twentieth course down, 4$\frac{1}{2}$″ from N.E. angle, crack continuous. Cracks in several places fourteenth course down.
4.52	238	114·70	49·93	1$\frac{7}{16}$	E. side, tenth course down at centre, split through header.
4.52$\frac{1}{2}$	240	115·70	50·36	1$\frac{1}{2}$	Cracks opening, and pier $\frac{1}{8}$″ wider.
—	245	118·19	51·45	1$\frac{9}{16}$	
4.54	250	120·68	52·53	1$\frac{5}{8}$	Cracking continuing, cracks joining up.
—	254	122·67	53·40	1$\frac{11}{16}$	
—	265	128·15	55·78	1$\frac{3}{4}$	
4.59$\frac{1}{2}$	280	135·62	59·05	1$\frac{13}{16}$	Jerk in pier and loud crack.
5.1	290	140·60	61·20	1$\frac{7}{8}$	Movements in pier and steady falling of mortar. Pier $\frac{1}{4}$″ wider.
—	295	143·09	62·30	1$\frac{15}{16}$	
5.3	300	145·58	63·37	2	Pier well cracked all over.
5.4	310	150·56	65·54	2$\frac{1}{16}$	
—	313	152·05	66·19	2$\frac{1}{8}$	
—	319	155·03	67·48	2$\frac{3}{16}$	
5.5	320	155·54	67·70	2$\frac{1}{4}$	Cracked right down both closers, S. face.
—	327	159·02	69·22	2$\frac{5}{16}$	
5.6$\frac{1}{2}$	330	160·52	69·89	2$\frac{3}{8}$	
—	338	164·50	71·61	2$\frac{7}{16}$	Pressure fell.
—	335	163·01	70·96	$\frac{19}{32}$ and continuing	N. face, covered with fine vertical splits.
5.8$\frac{1}{2}$	340	165·50	72·04		N.E. corner, twelfth to fifteenth course down, piece fell out, 3″ × 3″ × 4$\frac{1}{2}$″ on plan.
—	347	168·98	73·56		Gauge fell from this down to 200, when the pier collapsed. A portion about eight courses high with pyramidal top remained.

Pier No. 24.—Blue Bricks from Rowley Regis, in Lime Mortar 1 to 2.

6′ 0¼″ high; 18¼″ × 18½″; sectional area 2·345 sq. ft.

Built 9th August 1895; crushed 17th June 1896. Age 44⅞ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
9.22	10	1·16	·49	—	In bearing. Crack in joints in courses four to six from top on E. face before pressure was applied.
—	20	6·14	2·52	4/32	
—	40	16·10	6·87	6/32	
—	65	28·55	12·17	8/32	
—	80	36·02	15·36	9/32	
9.34	90	41·00	17·48	—	
—	97	44·48	18·97	10/32	Mortar in top bed spalling.
9.39½	110	50·96	21·73	11/32	
—	125	58·43	24·93	12/32	
9.46	130	60·92	25·98	—	N. side, second course, vertical crack at centre joint.
—	140	65·90	28·10	13/32	Fifth course down, S. face, bed squeezing slightly.
—	147	69·38	29·59	14/32	Face of other mortar beds also squeezing out.
—	164	77·85	33·20	15/32	
9.52	170	80·84	34·47	16/32	Internal crack heard.
—	185	88·31	37·66	17/32	
9.54	190	90·80	38·72	—	Top five beds, S. face, crumbling.
—	194	92·79	39·57	18/32	
9.55	200	95·78	40·84	—	N. side, twelfth course, 4½″ from N.W. angle, vertical crack in brick.
—	201	96·27	41·05	19/32	Sharp crack heard and mortar dropping.
9.56½	210	100·76	42·97	20/32	W. face, top course, 2½″ from N.W. angle, vertical crack. Mortar falling freely from top five beds.
9.58	220	105·74	45·09	21/32	Crack S. face, E. angle, tenth to twelfth course, and W. angle fourteenth to twentieth course down.
—	225	108·23	46·15	22/32	
9.59½	240	115·70	49·34	23/32	N. side, third course, slight spall of centre header.
10.0	250	120·68	51·46	24/32	Sharp crack heard.
10.1	260	125·66	53·46	—	Crack W. face seventh to ninth course down N. angle.
10.2	270	130·64	55·58	—	E. face, ninth course down, 4½″ from S.E. angle, and also 4¾″ from N.E. angle split; eleventh course, 4¾″ from S.E. angle split.
—	272	131·63	56·13	26/32	
10.3¼	280	135·62	57·83	27/32	Crack two courses down S.W. angle. E. face, thirteenth course, spall. N. face, eighth course, 1½″ from N.E. angle split. N. face, tenth course, 5″ from N.E. angle split.
10.4½	290	140·60	59·96	28/32	N. face, diagonal crack developing from sixth course, at 7″ from N.W. angle to tenth course at 5″ from N.E. angle.
10.5½	300	145·58	62·08	29/32	N. side, 5¼″ from N.W. angle, eighteenth course, vertical crack. Beds crumbling all over.
—	312	151·55	64·62	30/32	Slight jump of pier. E. side, ninth course, 4½″ from N.E. angle, two vertical cracks, 1/16″ apart.
10.8½	320	155·54	66·32	31/32	N. side the diagonal crack slightly opening. Pier cracking and spalling at other places.
10.11½	325	158·03	67·39	—	Detached vertical cracks over all faces. E. face in best condition.
10.13	330	160·52	68·45	33/32	
10.16½	340	165·50	70·58	34/32	N.W. angle bulging at fifteenth bed, and N. face of header at angle fell off.
—	345	167·99	71·64	35/32	
—	349	169·98	72·49	36/32	
10.22	355	172·97	73·76	37/32	Loud cracks at short intervals.
—	350	170·48	72·70	—	Pressure falling.
10.26	340	165·50	70·58	—	Bricks spalling and cracks developing.
10.29	300	145·58	62·08	—	Pier shearing from south downwards towards north, and collapsed. A pyramid about eight courses high left at base. (See fig. 13, p. 81.)

Pier No. 25.—Stock Bricks from Sittingbourne, in Portland Cement Mortar 1 to 4.

6′ 0″ high; $18\frac{1}{4}'' \times 18''$; sectional area 2·281 sq. ft.
Built 1st August 1895; crushed 17th June 1896. Age $45\frac{6}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
11.4	11	1·66	·73	—	In bearing. Cement very hard on face.
—	19	5·64	2·47	$\frac{1}{32}$	
—	24	8·13	3·56	$\frac{1}{16}$	
11.8	28	10·12	4·43	$\frac{3}{32}$	Bottom S.W. brick crushing at angle, due to winding in iron plate.
—	33	12·61	5·52	$\frac{4}{32}$	E. side, bottom course, N.E. corner crushing.
—	36	14·10	6·18	$\frac{5}{32}$	
—	43	17·59	7·71	$\frac{6}{32}$	
$11.12\frac{1}{2}$	50	21·08	9·24	$\frac{7}{32}$	N. side, bottom course, N.E. corner crushing. Crack up two courses, S.W. angle, through brick.
11.19	61	26·55	11·64	$\frac{8}{32}$	
11.26	70	31·04	13·61	—	N.W. corner, top brick split and flaked. Crack S.E. top at closer, S. face, four courses down.
11.28	75	33·53	14·70	$\frac{9}{32}$	
11.31	85	38·51	16·88	$\frac{10}{32}$	S.E. crack spreading down and out, eight courses down at closers.
11.33	90	41·00	17·97		E., W., and N. faces practically sound.
—	99	45·48	19·94	$\frac{11}{32}$	S.E. crack ten courses down.
11.37	105	48·47	21·25	—	E. side, sixth course, centre header crushing horizontally at centre. N. side, second to tenth course, $4\frac{1}{2}''$ from N.E. angle, vertical crack.
11.39	110	50·96	22·34	$\frac{12}{32}$	Pressure falling.
—	108	49·96	21·90	$\frac{13}{32}$ and continuing	
11.41	102	46·97	20·59		Pier split and collapsed. (See fig. 14, p. 81.)

*** Cement was set hard, and adhered well to bricks. Near the heart of pier was some slight dampness.

Pier No. 26.—Stock Bricks from Sittingbourne, in Portland Cement Mortar 1 to 4.

6′ $0\frac{1}{4}''$ high; $18\frac{3}{16}'' \times 18\frac{7}{16}''$; sectional area, 2·328 sq. ft.
Built 1st August 1895; crushed 17th June 1896. Age $45\frac{6}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
12.8	11	1·66	0·71	Through an accident in setting the gauge, the compression notes are useless.	In bearing.
—	46	19·08	8·19		N. face, top course, split and spalled at N.W. corner.
$12.12\frac{1}{2}$	50	21·08	9·05		N. face, end of header shattered, and closer spalling a little. Crack top S.W. angle in brick; iron plate bearing on this point. S.E. angle free.
12.19	70	31·04	13·33		Crack four courses up at bottom, in centre of W. face. E. face, top N.E. corner, spalled at angle. N. face, first and second courses, 2″ from N.W. angle, vertical split.
12.21	80	36·02	15·47		Crack nine courses up; S. face, S.W. angle at closer. N. face, a crack starting at eighth course from bottom, $4\frac{1}{2}''$ from N.W. angle, and extending to bottom of pier at $7\frac{1}{2}''$ from N.W. angle.
12.22	85	38·51	16·54		Last mentioned crack continuing upwards to eighth course from top, and opening Other cracks opening $\frac{3}{16}$.
$12.23\frac{1}{2}$	87	39·50	16·96		New cracks developing and pressure falling.
12.25	75	33·53	14·40		Collapse. (See fig. 15, p. 83.)

*** The top eleven courses practically solid, and an approximate but ill-formed cone at bottom. The iron plate at bottom was in winding $\frac{1}{4}''$; but this does not appear to have affected the ultimate collapse. The cement was set, but some vertical joints were not properly filled.

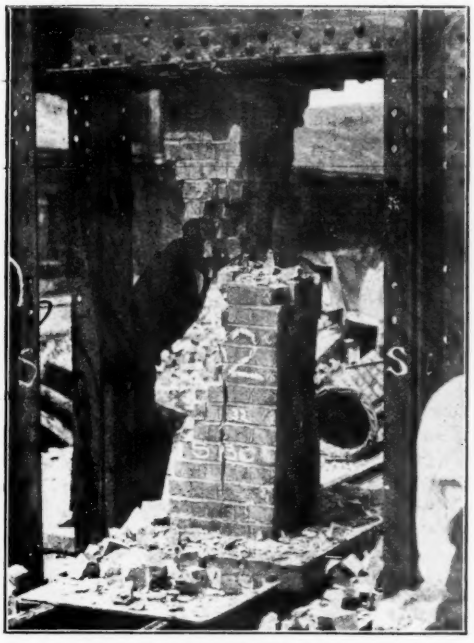

FIG. 19.—PIER 32: PAUSE IN COLLAPSE.

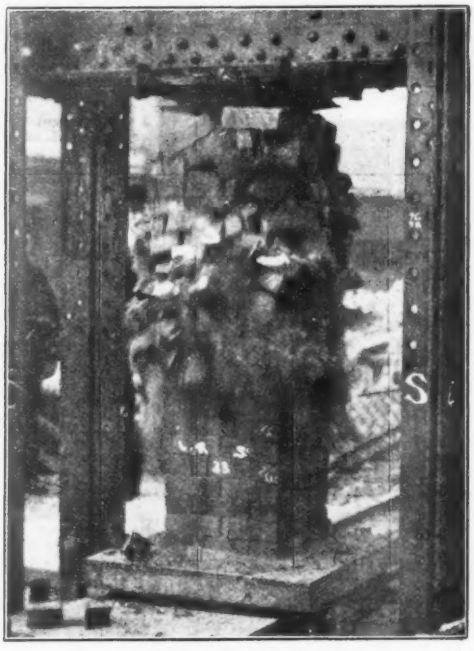

FIG. 20.—PIER 33 BURSTING.

Pier No. 27.—Gault Bricks from Burham, Kent, in Portland Cement Mortar 1 to 4.

6′ 0⅜″ high; 18⅜″ × 18⅛″; sectional area 2·313 sq. ft.
Built 1st August 1895; crushed 17th June 1896. Age 45⅝ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
2.5½	10	1·16	0·50	—	In bearing.
2.7	35	13·61	5·88	1/32	
2.7¼	40	16·10	6·96	2/32	
—	60	26·06	11·22	3/32	
2.8	70	31·04	13·37	4/32	
—	80	36·02	15·57	—	
2.10½	93	42·49	18·37	5/32	E. face, N.E. corner, first to third course cracked, and N. face at the corner coming off. N. face, 7½″ from N.E. corner, fourth to twelfth courses split; also at 4½″ from E. top to seventh course split; also close to N.E. angle, fourth course, five vertical splits in stretcher (all N. face).
2.13	100	45·98	19·87	—	E. face, top four courses split.
2.14	105	48·47	20·95	6/32	
2.15½	110	50·96	22·03	—	Cracks on N. and S. faces extending and opening, W. face still sound.
2.24	125	58·43	25·26	7/32	Crack on S. face opening 5/16; N.E. corner bulging from top to eighth course, crack open 3/16; N. face five courses spalling.
2·26	128	59·92	25·90	8/32	Pressure falling.
2.29	125	58·43	25·26	—	Pier crippled at N.E. corner for upper half of its height.
2.31½	127	59·42	25·68	10/32	
2.36	130	60·92	26·33	—	Movements in pier.
2.38½	127	59·42	25·68	—	Pier generally crippled and quietly moving.
2.40	120	55·94	24·18	—	Pier split down and opened. A rough cone formed at top. (See fig. 16, p. 83.)

*** The cement was set and hard, but slightly moist where much in bulk at heart of pier.

Pier No. 28.—Gault Bricks from Burham, Kent, in Portland Cement Mortar 1 to 4.

6′ 0¾″ high; 18⅜″ × 18¼″; sectional area 2·329 sq. ft.
Built 1st August 1895; crushed 17th June 1896. Age 45⅞ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
3.8½	11	1·66	0·71		In bearing.
—	14	3·15	1·35	1/32	
—	16	4·14	1·77	2/32	
3.11½	20	6·14	2·63	3/32	
—	29	10·62	4·55	4/32	
3.15	40	16·10	6·91	5/32	
—	63	27·55	11·82	6/32	
—	86	39·00	16·74	7/32	
3.29	110	50·95	21·88	—	Pier sound up to this pressure; when on W face, top course, ¼″ from N.W. angle, a vertical crack appeared.
3.30	115	53·45	22·94	—	Crack four courses down S. face at E. closer.
—	119	55·44	23·80	8/32	
3.33½	125	58·43	25·08	—	Additional cracks at top on S.W. and E. faces, but the N. face still sound.
3.43	140	65·90	28·29	9/32	A sharp crack heard, and cracks appearing on N. face at top.
3.46½	150	70·88	30·43	—	S.E. crack extended twelve courses down and opening slightly.
3.50	165	78·35	33·64	10/32	Pressure rapidly falling. Sides were crippled, bulged gently, and faces fell out. Then, after a pause, the top cone fell. (See fig. 17, p. 83.)

*** Cement set and adhering well to bricks, but not quite dry in heart of pier. Joints near top of pier not well flushed up.

Pier No. 29—Red Bricks from Ellistown, near Leicester, in Portland Cement Mortar 1 to 4.

6′ 0¼″ high; 18⅛″ × 18⅜″; sectional area 2·313 sq. ft.
Built 1st August 1895; crushed 17th June 1896. Age 45⅞ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
4.20	12	2·15	0·92		In bearing.
4.21	20	6·14	2·65	1/32	
4.22	30	11·12	4·80	2/32	
—	38	15·10	6·52	3/32	
4.23½	50	21·08	9·11	4/32	
—	68	30·04	12·98	5/32	
—	93	42·49	18·37	6/32	
4.32	120	55·94	24·18	7/32	E. face, bottom course, flake off closer nearest to S.E. angle.
4.33½	130	60·92	26·33	—	Crack two courses down S. face, top S.E. corner.
4.35	140	65·90	28·49	—	Cracks four courses down S.W. top corner at closers.
—	167	79·34	34·30	8/32	
4.49	200	95·78	41·40	9/32	Slight crushing of bottom bed on iron plate.
4.54	220	105·74	45·71	—	Cracks developing and opening slightly.
—	230	110·72	47·86	10/32	
—	—	—	—	11/32	Compression continuing without increase of pressure.
5.2	170	80·84	34·95	—	Pressure falling, pier crippled generally at centre of each face, and final collapse very sudden.

*** Cement set and adhering well to bricks.

Pier No. 30.—Red Bricks from Ellistown, near Leicester, in Portland Cement Mortar 1 to 4.

6′ 0¼″ high; 18⅛″ × 18$\frac{5}{16}$″; sectional area 2·305 sq. ft.
Built 1st August 1895; crushed 19th June 1896. Age 46¼ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
9.36	10	1·16	0·50	—	In bearing. S.E. top corner free; top in winding for 6″ on E. face and 6″ on S. face.
—	17	4·64	2·01	$\frac{2}{32}$	
—	19	5·64	2·41	$\frac{3}{32}$	
—	25	8·63	3·74	$\frac{4}{32}$	
—	29	10·62	4·60	$\frac{5}{32}$	
9.40	40	16·10	6·98	$\frac{6}{32}$	
—	50	21·08	9·14	$\frac{7}{32}$	
—	64	28·05	12·16	$\frac{8}{32}$	
9.41½	70	31·04	13·46	—	Small spalls at bottom on E. face.
9.42½	80	36·02	15·62	$\frac{9}{32}$	
9.45	90	41·00	17·78	—	Crack through S.W. bottom angle brick.
9.47½	100	45·98	19·94	$\frac{10}{32}$	Crack through second course from S.W. angle at closer.
9.51¼	110	50·96	22·10	—	Bricks split at bottom of pier and the bed (on plate) distressed at N.E. and S.W. corners, owing to faulty top bed.
9.56½	120	55·94	24·26	$\frac{11}{32}$	Crack in third course down centre of S. face in header; small cracks in top and bottom courses N. and E. faces.
10.4½	144	67·89	29·45	—	Top crack on S. face five courses down, running eastward, and in centre of header.
10.8½	150	70·88	30·75	—	S.W. bottom crack three courses up on S. and W. faces.
10.11½	160	75·86	32·91	$\frac{12}{32}$	N.E. angle of top course coming out. N. face, bottom course, face of brick next N.E. angle much damaged, spalled, and cracked; mortar crushing out second joint S.W. angle.
10.26½	178	84·82	36·79	$\frac{13}{32}$	
10.27½	180	85·82	37·23		
10.42	200	95·78	41·55	—	E. face, bottom course, whole face split off; N. face ditto for 7½″ from N.E. angle.
10.45	194	92·79	40·25	—	Gauge fell to 194.
10.47½	200	95·78	41·55		
10.57	230	110·72	48·03	$\frac{14}{32}$	Slight movement at top N.E. angle.
10.58½	250	120·68	52·35	$\frac{15}{32}$	Small pieces falling.
—	253	122·17	53·00	—	Pressure falling.
—	240	115·70	50·19	$\frac{16}{32}$	
—	230	110·72	48·03	$\frac{17}{32}$	Pier opened suddenly and evenly from the top towards N.E. and W., but only a small angle fell towards the S.

*** A pyramid at the top was visible from the S. as the pier fell. There was a poorly formed pyramid at the bottom four courses high. Stock bricks used as closers in several places in five bottom courses.

Pier No. 31.—Blue Bricks from Rowley Regis, in Portland Cement Mortar 1 to 4.

6″ 0½″ high ; 13$\frac{9}{16}$″ × 13½″ ; sectional area 1·271 sq. ft.
Built 31st July 1895 ; crushed 19th June 1896. Age 46$\frac{2}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
11.27	10	1·16	0·91	—	In bearing.
11.29	20	6·14	4·83	$\frac{1}{32}$	
11.30½	40	16·10	12·66	$\frac{2}{32}$	
11.31	60	26·06	20·50	—	Slight sound.
11.31½	70	31·04	24·42	$\frac{3}{32}$	Ditto.
11.32	90	41·00	32·25	—	Ditto.
11.32½	100	45·98	36·17	—	Sharp audible crack.
11.35	101	46·47	36·56	—	Audible crack and slight visible jump of pier. Crack in second course up S.E. angle.
11.37	105	48·47	38·13	—	Crack three courses down S.E. top, 4½″ from E. face.
11.39	113	52·45	41·26	$\frac{4}{32}$	
11.39½	120	55·94	44·01	—	Top crack four courses down.
11.40½	130	60·92	47·93	—	Top crack five courses down.
11.41½	140	65·90	51·84	$\frac{5}{32}$	Small cracks in top and bottom courses.
11.45	180	85·82	67·52	$\frac{7}{32}$	Cracks opening.
11.46½	210	100·76	79·27	$\frac{8}{32}$	N.E. corner at top, showing several cracks, continuing downwards.
11.47	220	105·74	83·19	$\frac{9}{32}$	
—	235	113·21	89·07	—	E. side crippled from second down to seventh course. N. side split from top to twelfth course, 4½″ from N.E. angle.
11.49½	240	115·70	91·03	—	Pier bending slightly, convexity towards W.
—	242	116·69	91·80	—	Pressure began to fall.
—	200	95·78	75·35	—	Pier burst quickly. (See fig. 18, p. 83.)

*** The N.W. angle suffered most, only three courses of that angle remaining standing. The damage to the bricks was very fairly distributed and general ; only about half a dozen bricks remained whole.

Pier No. 32.—Blue Bricks from Rowley Regis, in Portland Cement Mortar 1 to 4.

6′ 0$\frac{1}{16}$″ high ; 18″ × 18$\frac{1}{4}$″ ; sectional area 2·282 sq. ft.
Built 27th July 1895 ; crushed 19th June 1896. Age 46$\frac{2}{7}$ weeks.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
12.15	13	2·65	1·16	—	In bearing.
12.21½	110	50·96	22·33	$\frac{1}{32}$	
12.27	160	75·86	33·24	—	Slight sounds at top N.E. corner, and movement of plaster cap.
12.28	170	80·84	35·42	$\frac{2}{32}$	Sound of crack. Hair cracks in top course N.E. angle.
—	178	84·82	37·16	—	Crack four courses up centre S. face.
12.33	200	95·78	41·97	—	Sharp audible crack. Crack eight courses up centre N. face ; also two bottom courses split at centre N. face.
—	205	98·27	43·06	$\frac{3}{32}$	
12.35	210	100·76	44·15	—	Top N.E. corner, cracks extending to second course.
12.38½	230	110·72	48·51	—	Sharp audible cracking sounds.
12.39	240	115·70	50·70	—	N. face, ninth course from bottom, 7½″ from N.E. angle, vertical split.
12.39½	250	120·68	52·88	—	N. face, ninth course from bottom, continuing downwards and getting nearer to centre line of face.
12.40	260	125·66	55·06	$\frac{4}{32}$	N. face, ninth course, split now extending right down to bottom of pier at centre of N. face. Crack on S. side extended up to centre of pier.
12.40½	270	130·64	57·24	—	Crack on N. side extended up to centre of pier.
12.41½	290	140·60	61·61	$\frac{5}{32}$	
—	310	150·56	65·97	—	E. face, third course from top, 4½″ from N.E. angle, split.
12.44	340	165·50	72·52	$\frac{7}{32}$	Spalling at top. Pier split right down centre N. and S. faces.
—	343	166·99	73·17	$\frac{8}{32}$	Pressure fell.
—	310	150·56	65·97	—	N. face, N.E. corner, face off three top courses.
—	289	135·62	59·43	—	Chief splits open ¼″.
—	270	130·64	57·24	—	Still opening on N. and S. faces, but E. and W. sides fairly sound.
12.47½	310	150·56	65·97	—	Rapid falling of small spalls followed by collapse. (See fig. 19, p. 89.)

*** The closers were found to be all stocks ; no blue brick closers could be found in the interior of this pier ! Cement adhered fairly well.

Pier No. 33.—Red Bricks from Ellistown, near Leicester, built in Sand.

5′ 11⅜″ high; 18″ × 17⅞″; sectional area 2·234 sq. ft.
Built and crushed 19th June 1896.

Time	Pressure on gauge. Pounds per square inch	Total real pressure in tons	Pressure per square foot of pier in tons	Compression in inches	Notes
4.30	13	2·65	1·18	—	In bearing.
4.31	16	4·14	1·85	4/32	
—	18	5·14	2·30	6/32	
4.31½	20	6·14	2·74	8/32	Spread out ¼″ wider at centre of height.
—	23	7·63	3·41	12/32	
—	25	8·63	3·86	14/32	
—	27	9·62	4·30	16/32	
4.33	30	11·12	4·97	18/32	Inside brick heard to break. Crack in eleventh course S.W. angle brick S. face, and six courses down W. side. S.W. closer line.
—	32	12·11	5·42	20/32	
—	34	13·11	5·86	22/32	Cracks S. face, eleventh and fifteenth courses, at each closer. Pier ⅜″ wider.
—	39	15·60	6·98	24/32	
4.36	40	16·10	7·20	—	Crack S. face, S.E. bottom angle, closer line. N. face, seventh course, 4½″ and 7″ from N.W. angle, splits.
4.37¼	44	18·09	8·09	28/32	Crack on W. face open 5/16″ wide.
—	47	19·58	8·76	30/32	Breaks heard; visible movements in the pier. N. face, seventh course, 8″ from N.E. angle, split.
4.39	50	21·08	9·43	32/32	N. face, ninth course, 4½″ from N.W. angle, continuation of the split noted at 40 lb. E. face, fourth, fifth, sixth, seventh, and eighth courses, irregularly split. S. face, cracks in fourth, seventh, and eighth courses.
4.40½	56	24·06	10·76	34/32	N. face, thirteenth course, 3″ from N.W. angle, split. W. crack down ten courses.
—	58	25·06	11·21	36/32	
4.42	60	26·06	11·66	38/32	N. face, third course, 4½″ from N.E. angle, split.
—	62	27·05	12·10	40/32	
4.43	65	28·55	12·77	42/32	E. face, fifth to eighth course, at 4½″ from S.E., bad state; split open ½″. S. face, two cracks down eleven courses, branching from crack at top. Pier 1″ wider at eighth course.
—	65	28·55	12·77	44/32	E. face, seventh to eleventh course. at 4½″ from N.E. angle, split.
4.46	70	31·04	13·89	—	Very steady run of sand from seventh bed. S. crack thirteen courses down at W. angle. Pressure falling, pier bulging.
—	75	33·53	15·00	—	Cracks on S. face, sixteen courses down. Pier 2″ wider at eighth course. W. face of pier straightened, somewhat reducing bulge.
—	68	30·04	13·44	—	
—	75	33·53	15·0	—	Sand running freely from twelfth to fourteenth beds.
4.50	68	30·04	13·44	—	Crushed and fell, bulging out most at seventh course; eight bottom courses left standing. (See fig. 20, p. 89.)

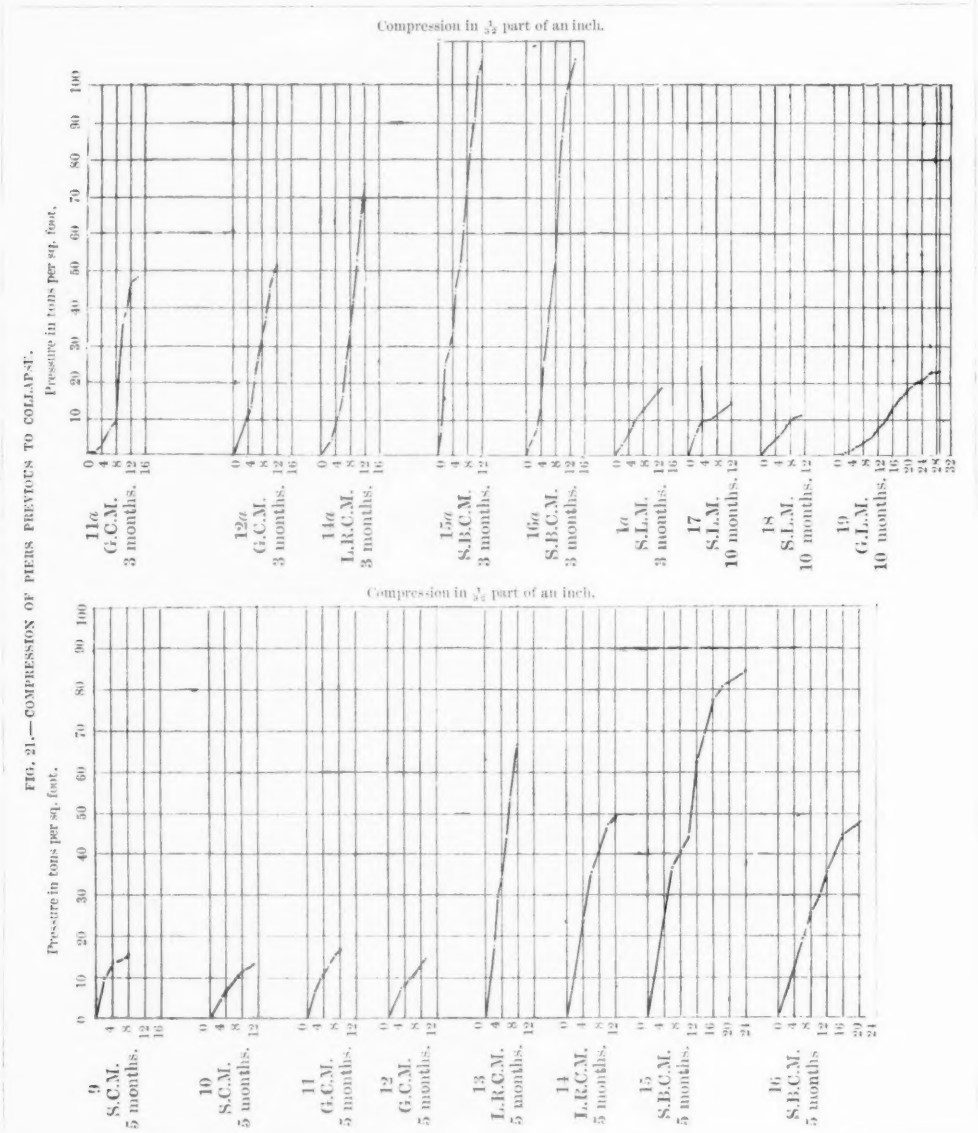
Compression in 1/32 part of an inch.
Pressure in tons per sq. foot.
11a G.C.M. 3 months.
12a G.C.M. 3 months.
14a L.R.C.M. 3 months.
15a S.B.C.M. 3 months.
16a S.B.C.M. 3 months.
1a S.L.M. 3 months.
17 S.L.M. 10 months.
18 S.L.M. 10 months.
19 G.L.M. 10 months.
Compression in 1/32 part of an inch.
Pressure in tons per sq. foot.
9 S.C.M. 5 months.
10 S.C.M. 5 months.
11 G.C.M. 5 months.
12 G.C.M. 5 months.
13 L.R.C.M. 5 months.
14 L.R.C.M. 5 months.
15 S.B.C.M. 5 months.
16 S.B.C.M. 5 months

FIG. 21.—COMPRESSION OF PIERS PREVIOUS TO COLLAPSE.

Though, as before stated, it is not now intended to dogmatise upon the results of the unfinished series of experiments, a table has been prepared [p. 96] showing the results of the crushing of each of the piers, and the averages obtained from the different classes of brickwork. It will be readily noticed, in looking down the columns, that something must have greatly disturbed these averages, as it would, for instance, be absurd to expect some of the descriptions to be weaker at ten months than at four. The cause, however, is not far to seek. The piers built as substitutes for those which the Committee found badly built

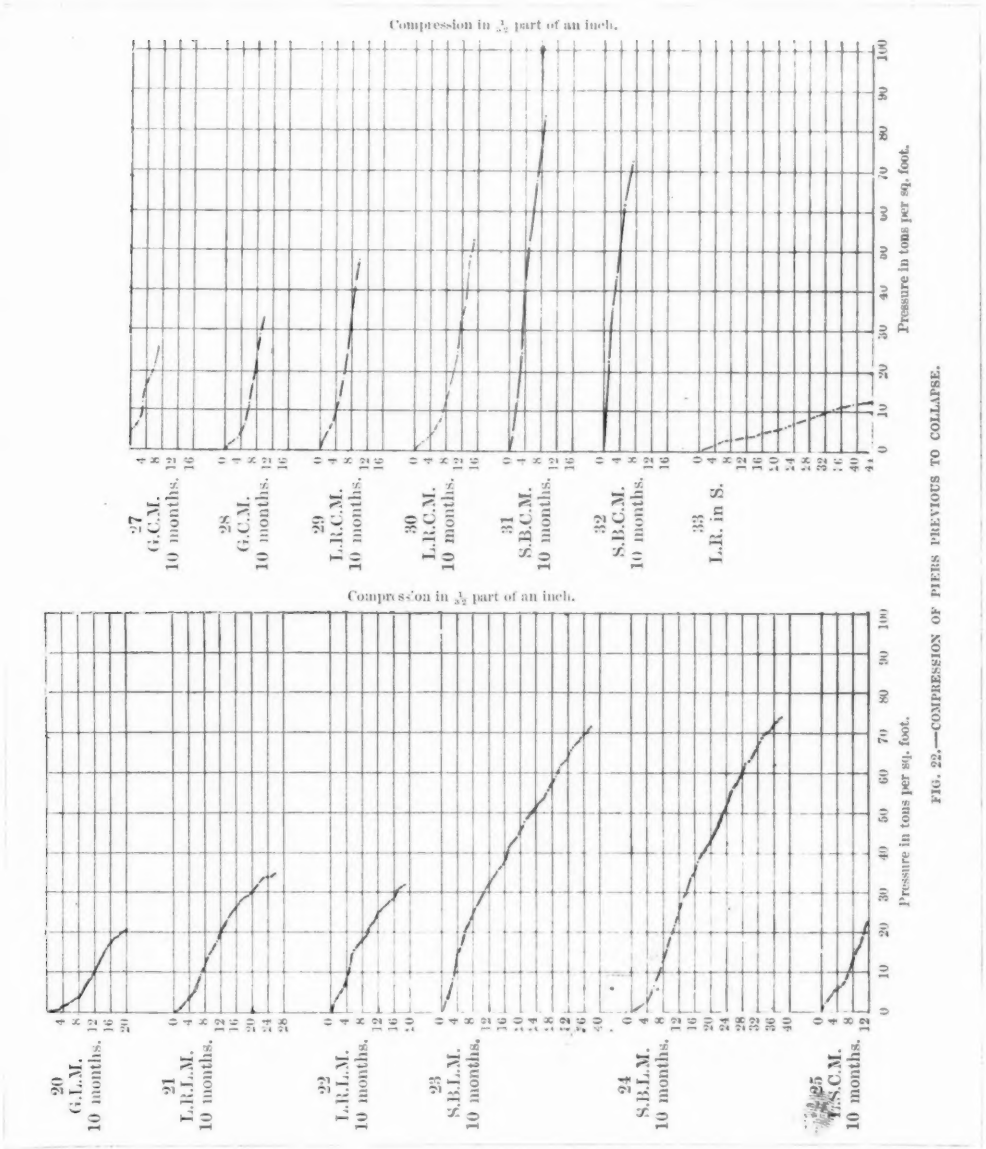
Compression in $\frac{1}{32}$ part of an inch.
Pressure in tons per sq. foot.
27 G.C.M. 10 months.
28 G.C.M. 10 months.
29 L.R.C.M. 10 months.
30 L.R.C.M. 10 months.
31 S.B.C.M. 10 months.
32 S.B.C.M. 10 months.
33 L.R. in S.
Compression in $\frac{1}{32}$ part of an inch.
Pressure in tons per sq. foot.
20 G.L.M. 10 months.
21 L.R.L.M. 10 months.
22 L.R.L.M. 10 months.
23 S.B.L.M. 10 months.
24 S.B.L.M. 10 months.
25 T.S.C.M. 10 months.

FIG. 22.—COMPRESSION OF PIERS PREVIOUS TO COLLAPSE.

in the first series were so superior to any of those reserved for the ten months' test that they raised the average for four months to beyond that obtained for the piers crushed at ten months. Taking therefore the original piers as specimens of what might be got in ordinary practice, one ought perhaps to reduce the averages to approximate to those obtained in the first instance from indifferent, which is indeed the ordinary manner of building.

Since writing the foregoing, the Committee have received from the Sheffield Society of Architects a report upon the samples sent them of the varieties of brick used by the Committee,

Crushing Loads in Tons per Square Foot.

—	Stocks			Gaults			Leicester Red			Staffordshire Blue		
			average 8·27			average 18·20			average 36·10			average 70·10
Bricks crushed at	No. 2.	10·41		No. 3.	21·82		No. 5.	29·03		No. 7.	69·22	
Brickwork in lime, 3 to 4 months	„ 1a.	18·28	14·34	„ 4.	22·03	21·92	„ 6.	31·55	30·74	„ 8.	79·39	74·30
Ditto ditto 10 months	No. 17.	14·11		No. 19.	22·93		No. 21.	34·35		No. 23.	73·56	
Ditto ditto ditto	„ 18.	10·97	12·54	„ 20.	20·27	21·60	„ 22.	33·89	34 12	„ 24.	73·76	73·66
Ditto in cement, 3 to 4 months	No. 9.	16·03		No. 11.	18·07		No. 13.	67·36		No. 15.	84·47	
Ditto ditto ditto	„ 10.	13·83	14·93	„ 12.	17·51		„ 14.	49·54		„ 16.	61·14	
Ditto ditto ditto	—			„ 11a.	48·10		„ 14a.	86·39		„ 15a.	108·25	
Ditto ditto ditto	—			„ 12a.	51·05	33·68	—		67·76	„ 16a.	97·90	87·04
Ditto ditto 10 months	No. 25.	22·34		No. 27.	26·33		No. 29.	47·86		No. 31.	91·80	
Ditto ditto ditto	„ 26.	16·96	19·65	„ 28.	33·64	29·98	„ 30.	53·00	50·43	„ 32.	73·17	82·48
Ditto in sand	—			—			„ 33.		15·00	—		

and a comparison between them and some varieties of Sheffield stocks crushed at the same time. The tests were made in a manner and with an exactness that left nothing to be desired, though it would appear that the machine at Professor Ripper's disposal was not sufficiently powerful to crush the Blue Bricks. Two of the descriptions of Sheffield stocks so tested proved to be half as strong again as an ordinary London stock, while a third was two and a half times as strong. Want of space forbids the publication of the report here, but an abstract appeared in last week's *Builder*, p. 495. There is a column appended to the Sheffield report which, in the opinion of the Committee, is unnecessary and misleading, and which is disposed of by the table annexed. The column referred to states the height of a building in feet to crush lowest bricks. It does not state how it would be proposed to build to the heights given in that column, but if with lime mortar and in an ordinary manner the figures given should be divided by seven or thereabouts to give the ratio between the resistance of bricks and of brickwork to crushing. The result thus obtained should be again divided by three, or some such figure, to arrive at a safe load or height. It will be urged that no wall of any great height would be built of the same thickness all the way up, and the pressure would be reduced by the distribution of the weight upon increasing areas, so that instead of dividing the heights given in the Sheffield report by twenty-one, it would in practice be sufficient to divide by ten. But even then no allowance is made for any weights the wall would be expected to carry, nor for the influences which the form, the length, and the thickness of the wall might have upon its strength.

THE SECOND SERIES OF BRICKWORK TESTS: APPENDICES.

By Professor UNWIN [*M.A.*], F.R.S.

I. DETERMINATION OF THE LOADS CORRESPONDING TO THE OBSERVED GAUGE PRESSURES FOR THE LARGE HYDRAULIC PRESS AT THE WEST INDIA DOCKS.

Some cylinders were prepared of good uniform copper rod. They were made very exactly as to diameter and length. Two of these were subjected to careful tests in a testing machine, and the compressions corresponding to different loads noted. Exactly similar copper cylinders were then crushed in the large hydraulic press at the West India Docks, and the compressions at different gauge pressures noted. Comparison of the testing-machine loads and gauge pressures for equal compressions of the cylinders gives the true effective crushing effort of the hydraulic press.

Two sizes of copper cylinders were used, about 0·94 and 1·10 inch diameter, and 1·88 and 2·13 inches in length respectively. They were placed in a crusher gauge between parallel steel surfaces. The load was applied through a spherical joint.

Fig. 23 shows the compression curves for two cylinders tested at Kensington in the 100-ton testing machine. The circles for the smaller cylinder, 1,681, and the crosses for the larger cylinder, 1,687, mark the observed compressions and loads. These points agree so closely with the curves that it appeared to be unnecessary to make further observations. The earlier compressions are elastic compressions, and are proportional to the loads. Beyond about 10 tons for the smaller and 17½ tons for the larger cylinder the compressions are plastic compressions and are much larger. The compressions were read to 1/1000th of an inch by an accurate vernier gauge. After the trials of the brick piers at the West India Docks on 31st December 1895 two similar copper cylinders were crushed in the hydraulic press, and the compressions corresponding to different gauge pressures were noted.

The following table gives the results of the observations:—

I.—Hydraulic Press at West India Docks, 31st December 1895.

Compression of two Copper Cylinders { Cylinder 1,688, diam. = 1·097″, length = 2·132″. „ 1,683, diam. = 0·938″, length = 1·879″.

Pressure by gauge. Pounds per sq. in.	Cylinder 1,688		Cylinder 1,683	
	Micrometer reading in inches	Compression in inches	Micrometer reading in inches.	Compression in inches
10	2·582	—	2·291	—
15	—	—	2·288	·003
20	2·581	·001	2·282	·009
25	2·580	·002	—	—
30	2·577	·005	2·274	·017*
40	2·570	·012	2·061	·230
50	2·456	·126	1·796	·495
60	2·209	·373	1·594	·697
70	2·005	·577	—	—
80	1·816	·766	1·293	·998
90	1·670	·912	—	—
100	1·558	1·024	—	—
110	1·468	1·114	—	—
130	1·355	1·227*	—	—

*The ram, in consequence of an air cushion in the press, moved not quite regularly, but in small jerks. Hence absolutely consistent results could not be expected. I think these two results the least regular and satisfactory of the series, and I have given less weight to them in calculating formula (2).

During the second series of tests two other copper cylinders were crushed in the hydraulic press, and the compressions at different gauge pressures noted. Table II. gives the results:—

II.—Hydraulic Press at West India Docks, 15th June 1896.

Compression of two Copper Cylinders { Cylinder 1,689, diam. = 1·094″, length = 2·133″.
,, 1,690, diam. = 1·094″, length = 2·132″.

Pressure by gauge. Pounds per sq. in.	Cylinder 1,689		Cylinder 1,690	
	Micrometer reading in inches	Compression in inches	Micrometer reading in inches	Compression in inches
20	2·350	—	1·454	—
30	2·338	·012	1·435	·019
40	2·322	·028	1·420	·034
50	2·078	·272	1·209	·245
60	1·832	·518	0·961	·493
70	1·637	·713	0·767	·687
80	1·440	·910	0·590	·864
90	1·342*	1·008	0·461	·993
100	—	—	0·353	1·101
110	—	—	0·255	1·199

* A correction of ·065 inch has been added to this reading as an allowance for the bending of the plate to which the measurements were taken.

Some observations were taken at higher gauge pressures, but on plotting the results they appeared to be irregular. It was found that with the higher pressures the plunger of the compression apparatus had become slightly bent. The friction of the bent plunger in the apparatus was quite sufficient to explain the anomalies.

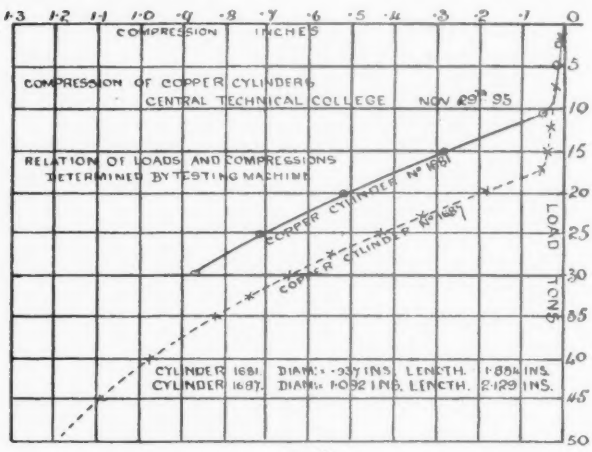
COMPRESSION INCHES
COMPRESSION OF COPPER CYLINDERS
CENTRAL TECHNICAL COLLEGE NOV 29th 95
RELATION OF LOADS AND COMPRESSIONS
DETERMINED BY TESTING MACHINE
COPPER CYLINDER No 1689
COPPER CYLINDER No 1687
LOAD TONS
CYLINDER 1689. DIAM. = ·93Y INS. LENGTH. 1·85M INS.
CYLINDER 1687. DIAM. = 1·092 INS. LENGTH. 2·129 INS.

FIG. 23.

By using the plotted curve of loads and compressions [fig. 23] it is now possible to tabulate the true loads corresponding to the observed gauged pressures for each of the four cylinders crushed in the hydraulic press. Tables III. and IV. give the relation of gauge pressures and loads, thus obtained, for 31st December and 15th June.

III.—Comparison of Gauge Pressures, calculated Loads, neglecting Friction, and true effective Loads of Ram at West India Docks, 31st December 1895.

Observed gauge pressure. lb. per sq. in.	Calculated load on ram, neglecting friction, &c. Tons	Effective loads from compression of copper cylinders		Mean effective load of ram in tons from plotted curve	Load calculated by formula (ae) in tons	Friction of ram. Tons
		Cylinder 1,683. Tons	Cylinder 1,688. Tons			
10	5·04	—	—	—	0·14	4·90
15	7·57	2·50	—	2·50	2·46	5·11
20	10·09	4·70	—	4·70	4·78	5·31
30	15·13	7·60	—	7·60	9·42	5·71
40	20·18	14·00	—	14·00	14·06	6·12
50	25·22	19·24	19·10	19·17	18·70	6·52
60	30·26	24·38	23·48	23·93	23·34	6·92
70	35·31	—	28·15	28·15	27·98	7·33
80	40·35	33·80	33·09	33·44	32·62	7·73
90	45·40	—	37·40	37·40	37·26	8·14
100	50·44	—	41·73	41·73	41·90	8·54
110	55·48	—	45·82	45·82	46·54	8·94
130	65·58	—	51·80	51·80	55·82	9·76

IV.—Comparison of Gauge Pressures, calculated Loads neglecting Friction, and true effective Loads of Ram at West India Docks, 15th June 1896.

Observed gauge pressure. lb. per sq. in.	Calculated load on ram, neglecting friction, &c. Tons	Effective loads from compression of copper cylinders		Mean effective load of ram in tons from plotted curve	Load calculated by formula in tons	Friction of ram. Tons
		Cylinder 1,689. Tons	Cylinder 1,690. Tons			
20	10·09	—	—	—	—	—
30	15·13	—	—	—	—	—
40	20·18	15·20	—	15·20	16·10	4·08
50	25·22	21·60	21·05	21·33	21·08	4·14
60	30·26	26·80	26·20	26·50	26·06	4·20
70	35·31	31·70	30·90	31·30	31·04	4·27
80	40·35	37·40	35·85	36·62	36·02	4·33
90	45·40	41·00	40·35	40·67	41·00	4·40
100	50·44	—	45·25	45·25	45·98	4·46
110	55·48	—	50·30	50·30	50·96	4·52

The hydraulic press has a ram 3 ft. $1\frac{7}{8}$ in. in diameter, or 1,130 sq. in. area. Hence, if there were no cup leather friction, or other force affecting the action of the press, except the water pressure, and if the pressure gauges were quite accurately graduated, then the crushing effort due to any gauge pressure would be given by the following equation:—

Let a = ram area in sq. in. = 1130;
p = gauge pressure in lb. per sq. in.

Then total pressure of ram on brick column

$$= P = \frac{pa}{2240} = 0{\cdot}5044\, p \text{ tons} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The cup-leather friction is, however, considerable, and the weight of the ram itself balances a portion of the water pressure.

A comparison of the results given in Table III. showed that the true load corresponding to any gauge pressure would be given very approximately for the condition in which the ram was on 31st December 1895 by the following formula:

$$P = 0{\cdot}464\, p - 4{\cdot}5 \text{ tons} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Similarly comparing the results in Table IV. it is found that the true load corresponding to any gauge pressure for the condition in which the ram was on 15th June 1896 is very approximately given by the formula

$$P = 0{\cdot}498\, p - 3{\cdot}82 \text{ tons} \quad . \quad (3)$$

It appears, therefore, from the observations that the friction of the ram was a little less on 15th June than on 31st December, or else that the gauges registered a little differently on those dates.

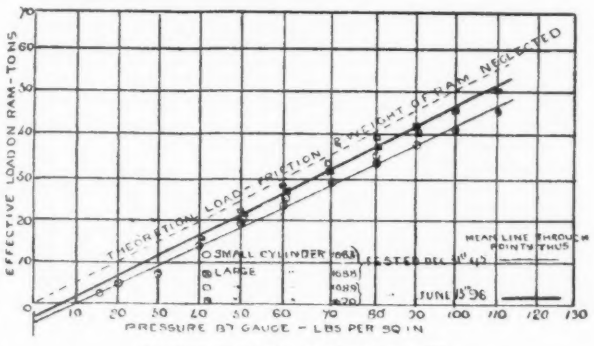
EFFECTIVE LOAD ON RAM - TONS
PRESSURE BY GAUGE - LBS PER SQ IN
THEORETICAL LOAD - FRICTION & WEIGHT OF RAM NEGLECTED
SMALL CYLINDER
LARGE
MEAN LINE THROUGH POINTS THUS
JUNE 15TH 96

FIG. 24.—CALIBRATION OF HYDRAULIC PRESS.

In Tables III. and IV. pressures calculated by these formulæ are given for comparison with those deduced directly from the compressions of the copper cylinders. It will be seen that the differences are nowhere important, and fall within the limits of errors of observation. It may be noted that in the case of the tests of each copper cylinder a different part of the ram

was used, and if the ram was not of uniform roughness some discrepancies would be shown in the observations.

Formula (2) has been used in reducing the results of the first series of tests of brick piers, and formula (3) in reducing the results of the second series of tests.

In fig. 24 all the observations on the crushing of copper cylinders in the hydraulic press have been plotted. The gauge pressures are taken as abscissæ, and the true loads deduced from the observed compressions as ordinates. The thick and thin lines give the relations of gauge pressures and loads on the two dates as calculated from formulæ (2) and (3). The figure shows that the formulæ agree very closely with the observations, and that the assumption that the results can be represented very approximately by a linear equation is true enough for all practical purposes.

II.—REPORT ON CRUSHING TESTS OF SAMPLES OF BRICKS USED IN BUILDING THE EXPERIMENTAL PIECES OF WALL.

Samples of three different kinds of bricks were sent.* These were prepared with plaster faces as usual. The following are the results of the crushing tests :—

Date of test	Description of brick	Dimensions in inches	Area crushed in square feet	Loads in tons		Stress in tons per square foot	
				Cracking	Crushing	Cracking	Crushing
1896.							
Nov. 12	Fletton (Plowman) . . .	8·6 × 4·15 × 2·65	0·248	33·9	50·23	136·8	202·7
,,	Fletton	8·6 × 4·20 × 2·70	0·251	50·0	50·95	199·4	239·0
,,	Blue Staffordshire . . .	4·2 × 4·30 × 2·70	0·125	44·9†	97·8	358·0	779·6

* These bricks were of different make from those used in the first experiments, the crushing tests of which are given in Vol. III. p. 348.

† Cracks apparently superficial only.

III.—REPORT ON TESTS OF LIME AND CEMENT USED IN THE CONSTRUCTION OF THE EXPERIMENTAL PIERS AT THE WEST INDIA DOCKS.

By arrangement parcels of lime and cement as used at the West India Docks and also some of the sand used there were forwarded to the Central Technical College. The quantity of sand was not sufficient for making more than a few briquettes, and therefore it was decided to use for most of the tests the standard washed and sifted sand which has been generally used for cement tests in this country. This sand is obtained from Leighton Buzzard. A few briquettes were made with the sand received from the West India Docks, and this is referred to below as special sand.

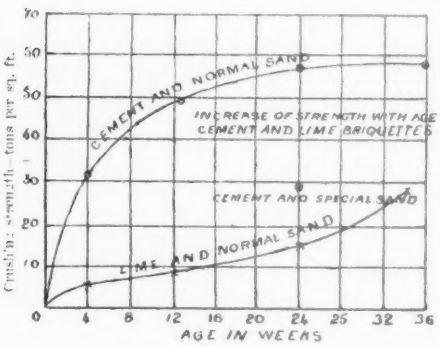

FIG. 25.—STRENGTH OF MORTARS.

The briquettes for compression tests were cubes of 3 inches length of side. They were made carefully, and when removed from the moulds were placed under water to harden. The results of the tests are given in the following tables. The results are also plotted in the diagram [fig. 25].

Lime Briquettes.—Composed of two of sand to one of lime by volume.

No. of specimen	Description	Date of making	Date of testing	Age. Weeks	Dimensions in inches: Crushed section	Dimensions in inches: Height	Area in square feet	Breaking load in tons	Crushing stress. Tons per square foot
		1895	1895						
L. 1	Standard sand	October 4	October 31	4	3·00 × 3·00	2·99	0·0625	0·344	5·50
L. 2	Ditto	October 4	October 31	4	3·00 × 3·00	3·02	0·0625	0·416	6·66
		1896							
L. 6	Ditto	October 7	January 7	13·1	3·00 × 3·05	3·00	0·0635	0·515	8·11
L. 7	Ditto	October 28	January 15	11·3	3·00 × 3·00	3·01	0·0625	0·585	9·36
L. 3	Ditto	October 4	March 20	24	3·00 × 3·00	2·99	0·0625	0·946	15·14
L. 4	Ditto	October 7	March 20	23·6	3·00 × 3·00	2·97	0·0625	0·961	15·38
L. 5	Ditto	October 7	March 20	23·6	3·00 × 3·00	3·01	0·0625	1·041	16·65
L. 9	Ditto	October 28	June 23	34	3·00 × 3·00	3·00	0·0625	1·697	27·15
L. 10	Ditto	October 28	June 23	34	2·99 × 3·00	3·00	0·0623	1·788	28·61
L. 11	Ditto	October 28	June 23	34	3·00 × 3·00	3·02	0·0625	1·876	30·02
L. 12	Ditto	October 28	June 23	34	3·00 × 3·00	3·00	0·0625	1·687	26·99

Mean strength at 4 weeks = 6·08 tons per sq. ft.
Ditto 12 weeks = 8·73 ditto

Mean strength at 24 weeks = 15·72 tons per sq. ft.
Ditto 34 weeks = 28·19 ditto

Cement Briquettes.—Composed of four of sand to one of cement by volume.

No. of specimen	Description	Date of making	Date of testing	Age. Weeks	Dimensions in inches: Crushed section	Dimensions in inches: Height	Area in square feet	Breaking load in tons	Crushing stress. Tons per square foot
			1895						
1	Standard sand	October 2	October 31	4	2·99 × 3·02	3·06	0·0627	2·196	35·03
3	Ditto	October 2	October 31	4	3·00 × 3·00	3·03	0·0625	1·741	27·86
			1896						
7	Ditto	October 3	January 7	13·7	3·00 × 3·00	3·02	0·0625	2·670	42·71
11	Ditto	October 3	January 7	13·7	3·00 × 3·03	3·00	0·0631	3·428	54·32
4	Ditto	October 2	March 19	24	3·00 × 3·02	3·00	0·0629	3·085	49·04
5	Ditto	October 2	March 19	24	3·00 × 3·01	3·00	0·0627	3·790	60·44
8	Ditto	October 3	March 19	24	3·02 × 3·00	3·00	0·0629	3·710	58·97
2	Special sand	October 2	March 19	24	3·01 × 3·02	2·99	0·0631	2·152	34·11
6	Ditto	October 2	March 19	24	2·98 × 3·00	3·00	0·0621	1·484	23·90
9	Standard sand	October 3	June 9	35·7	3·02 × 3·00	2·99	0·0629	4·124	65·56
10	Ditto	October 3	June 9	35·7	3·00 × 3·00	3·02	0·0625	3·368	53·89
12	Ditto	October 3	June 9	35·7	3·03 × 3·00	3·00	0·0631	3·559	56·40

Mean strength at 4 weeks = 31·45 tons per sq. ft.
Ditto 13·7 weeks = 48·52 ditto
Ditto 24 weeks = 56·15 ditto
Ditto 36 weeks = 58·62 ditto

Mean strength of briquettes made with same sand as that used in building the piers = 29·00 tons per sq. ft. at 24 weeks.

Composition of Mortars by weight and volume from weighings when making Briquettes at the Central Technical College.

Date	Mortar	Proportion by volume	Proportion by weight
October 1895	Cement and special sand	1 to 4	1 to 5·12
,,	Cement and standard sand	1 to 4	1 to 5·25
,,	Lime and standard sand	1 to 2	1 to 6·70
November 1896	Cement and special sand	1 to 4	1 to 4·20
,,	Cement and normal sand	1 to 4	1 to 4·40

*** The proportions by weight vary with the degree of packing of the cement and sand particles.

IV.—ON THE INFLUENCE OF FORM ON THE RESISTANCE TO CRUSHING.

It is very common to assume roughly that the resistance to compression in cases where bending does not enter is proportional simply to the area normal to the crushing pressure.

Hence in crushing tests specimens of more or less dissimilar form are crushed, and the crushing pressures per sq. in. are compared without reference to the influence which the proportions of the specimens may have had on the resistance to crushing.

Some of the earlier French writers on strength of materials pointed out that the crushing resistance per unit of area was only constant for a given material in geometrically similar prisms. Quite recently Bauschinger made experiments on this point, and still more recently Martens has made experiments on very various materials, with results which generally confirm those of Bauschinger.

Let f be the crushing resistance in pounds per sq. foot, A the area of the prism normal to the crushing pressure. Then for prisms of different heights h, but similar in cross-section, Bauschinger found that

$$f = \left(a + \beta \frac{\sqrt{A}}{h}\right),$$

where a and β were constants for any given material. For prisms of dissimilar cross-section, let c be the length of circumference of the section. Then

$$f = \left(a + \beta \frac{\sqrt{A}}{h}\right) \sqrt{\frac{\sqrt{A}}{\frac{1}{4}c}}.$$

These equations are empirical, and though broadly they agree with the results of such tests as have been made on natural stone and other materials, their verification is difficult. Different blocks, even of the same natural stone, vary enough in quality to make the results more or less discrepant.

It occurred to the author that ordinary red rubber bricks were uniform enough in quality to be suitable for such tests, and soft enough to be easily cut to prisms convenient for testing. The following tables give a series of such tests. The bricks were sawed roughly to the sizes required, and then rubbed to exact dimensions. They were tested carefully with a spherical joint interposed between them and the plate of the testing machine. Table I. gives a series of results on prisms of square section; Table II. a series of results on rectangular prisms of similar brick.

Table I.—Prisms of Red Rubber Brick, of square section, and of different proportions of height to length of side.

Dimensions: inches	Area crushed per sq. ft.	Cracking load. Pounds.	Cracking stress. Tons per sq. ft.	Crushing load. Pounds.	Crushing stress. Tons per sq. ft.
Height					
2·00 × 1·99 × 1·01	·028	6325	100·88	7733	123·33
2·01 × 2·01 × 1·01	·028	6222	99·23	8256	131·68
2·02 × 2·02 × 1·00	·028	6561	104·64	7709	122·95
Means:—			101·58		125·99
Height					
2·01 × 1·98 × 1·97	·028	5801	92·52	5801	92·52
1·99 × 1·98 × 2·01	·027	5986	98·94	5986	98·94
2·01 × 1·96 × 2·02	·028	4403	70·22	4403	70·22
Means:—			87·23		87·23
Height					
2·01 × 2·00 × 3·97	·028	3974	63·38	4266	68·04
1·99 × 1·98 × 3·96	·027	4965	82·07	4965	82·07
Means:—			72·73		75·06

Table II.—Rectangular Prisms of similar section, but different heights, of Red Rubber Brick.

Dimensions : inches	Area crushed per sq. ft.	Crushing load in Tons	Crushing stress. Tons per sq. ft.
Height			
2·84 × 4·70 × 2·33	·0927	7·740	83·50
2·83 × 4·70 × 2·32	·0927	7·810	84·25
Mean :—			83·875
2·84 × 4·70 × 4·63	·0927	6·660	71·84
2·84 × 4·71 × 9·28	·0927	6·385	68·88

It will be seen that in both series the crushing pressure per sq. foot varies very much with the height of the specimen, although all the test blocks were much too short for any lateral bending to occur. In fig. 26 the results of these two series of tests are plotted, and it will be seen that for each series the results plot very fairly as a straight line. The variation of crushing strength is really considerable when the uniformity of the material is considered.

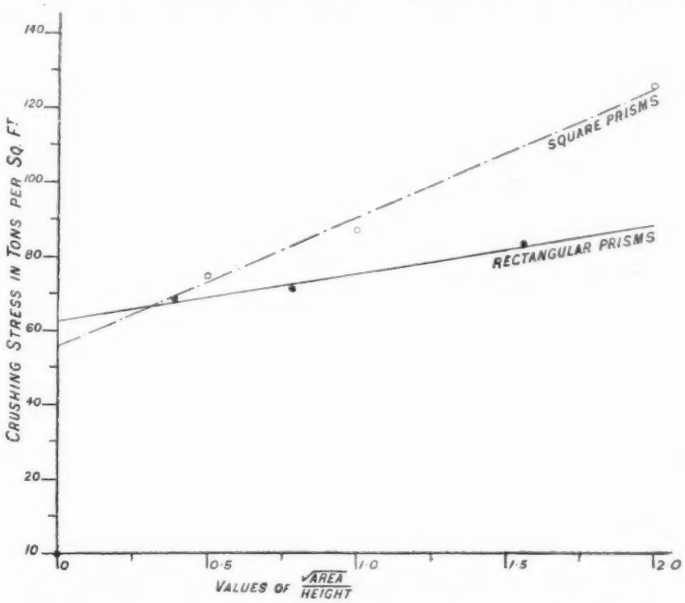

FIG. 26.—RED RUBBER BRICK PRISMS : VARIATION OF COMPRESSIVE STRENGTH WITH FORM.

It is necessary sometimes to test half bricks instead of whole bricks, because the whole brick requires a greater load than can be obtained in most testing machines. The uniformity of red rubber bricks suggested that they would be convenient material for determining whether there was a difference in the crushing pressure per sq. ft. depending on the difference of form of the whole and half brick. The following tests were therefore made, the bricks being rubbed to exact dimensions and crushed between millboards with a spherical joint interposed between the plate of the machine and the brick :—

Dimensions	Area crushed	Crushing		Mean stress. Tons per sq. ft.
		Load	Stress	
high	sq. ft.	tons	tons per sq. ft.	
9·0″ × 4·5″ × 2·95″	0·2813	22·420	79·70	79·70
4·5″ × 4·5″ × 2·95″	0·1406	10·560	75·12	72·90
4·5″ × 4·5″ × 2·95″	0·1406	9·935	70·67	

Hence it appears that the half brick is weaker than the whole brick in the ratio 1 to 0·9145. In other words, the half brick is weaker per sq. ft. on account of its dissimilarity of form by 8½ per cent.

*** The discussion on the foregoing Papers will appear in the issue of 31st December.

9, CONDUIT STREET, LONDON, W., *17th December* 1896.

CHRONICLE.

The Experiments on Brickwork.

The publication of the discussion which followed the Reports and supplementary Papers on Brickwork Tests read at the General Meeting of Monday, the 14th inst., is deferred to the next number. The Report which opened the proceedings was read by Mr. William C. Street [*F.*], Hon. Secretary of the Science Standing Committee, the tabulated statement of results being described and explained in detail by Mr. Max. Clarke [*A.*] with the aid of photographic views shown by the lantern. Most of these views are reproduced on foregoing pages. The speakers included Professor Unwin [*H.A.*], F.R.S., whose Papers are given as Appendices to the Report; Mr. Henry Dawson [*F.*], Mr. Wm. Woodward [*A.*], Mr. William White [*F.*], F.S.A., Mr. P. Gordon Smith [*F.*], Chairman of the Science Committee; Mr. John Slater [*F.*], Mr. Hugh Leonard [*H.A.*], well known as having made some very valuable tests of brickwork in Bengal in 1873, fully described at the time in *Engineering*, vol. xx. p. 103, and briefly summarised in the JOURNAL, Vol. II., 3rd Series, pp. 431, 593. Other speakers were Mr. Beresford Pite [*F.*], Mr. William Emerson, *Hon. Secretary*, Mr. F. T. Reade [*H.A.*], Mr. B. J. Capell [*A.*], and the President.

THE ROYAL GOLD MEDAL 1897.

Notice to Members.

On Monday, the 3rd February 1897, the Chairman presiding will announce to the General Meeting the name of the person the Council propose to submit to Her Majesty the Queen as a fit recipient of the Royal Gold Medal for the year 1897. Members of the Institute desiring to suggest names for the consideration of the Council should do so by letter addressed to the Acting Secretary prior to the 11th prox.

The British Archæological School at Athens.

Mr. Penrose, F.R.S., ex-President of the Institute, writes:—Some of the readers of the JOURNAL may be not unwilling to associate themselves with the effort that is being made by the Managing Committee of the British Archæological School at Athens to build a hostel in which the students of the school may have a somewhat collegiate manner of residence.

It has been from the very first a desire of the School Committee to provide lodgings for the students; but the low condition of the funds has rendered it hitherto impossible. There is now, however, a better prospect of its realisation, if an amount of additional help, which it seems reasonable to hope for, can be obtained.

Since the commencement of the school, ten years ago, the number of the students has increased in a satisfactory manner, and this year the number enrolled is not less than twelve; and the majority of these have informed the Committee that if such a hostel had been now existing, they would have gladly availed themselves of it.

At present the students must necessarily lodge at a distance, the very nearest convenient quarters being considerably over half a mile from the school; and they are scattered about in different hotels and lodgings, so that it is a real difficulty for them to make use of the school library and to study in the public museums on the same day.

The proposal is to erect a building for the purpose of supplying each student with a private room, combined also with a general common room and suitable offices, on the ground which was presented to the school by the Greek Government, so as to be in close connection with the school library, which is now well supplied with architectural and archæological books; and with the further advantage of being adjacent also to that of the American school, with which our school is, and always has been, in close alliance.

In addition to the advantages above mentioned, the more complete social intercourse amongst the students themselves, and their more ready access at all times to the Director, is an obvious gain, especially to the junior students.

Up to the end of November last, subscriptions amounting to £800 had been paid or promised, and about £500 more would enable a working instalment of the undertaking to be commenced at once; and this would be peculiarly advantageous if it could be started under the auspices of the present Director (Mr. Cecil Smith), who has taken very great interest in the project, but who is obliged to leave the post in June next.

Proposed Government Buildings, Jamaica.

Writing from Downing Street under date 4th December, the Secretary of State for the Colonies informs the President that Mr. W. H. Harrison has been selected by the Government of Jamaica to be the architect for the proposed public buildings in Kingston, Jamaica. Mr. Harrison, as will be seen by reference to the JOURNAL of the 12th ult., p. 41, was one of the four nominated by

the Council for the work, the others being Mr. Frank T. Baggallay, Messrs. Gibson & Russell, and Mr. Beresford Pite.

The late William Alphonsus Purdue [*A.*].

Mr. W. A. Purdue, who had been an Associate of the Institute since 1882, died of bronchitis on the 14th ult., after two days' illness, in his 72nd year. The deceased, who was the third son of the late Mr. Thomas Purdue, a Commissioner of Income Tax at Somerset House, was born at Ringwood, Hampshire, and was articled to Mr. Samuel Beazley, the architect of the Lyceum, Adelphi, and St. James's Theatres, in whose office he had as colleagues Mr. (now Professor) T. Roger Smith and Mr. W. Boucher. During his apprenticeship he entered as a student at the Institute, and also at the Architectural School of the Royal Academy. At the conclusion of his articles he entered the office of Mr. John Johnson, of the Adelphi, an accomplished draughtsman and a skilful architect, where he acquired great facility with his pencil, which he was enabled to exercise during an extensive tour on the Continent, chiefly in Italy, during the years 1854 to 1859. On his return to England he took chambers in John Street, Adelphi, where he remained for several years, occupying himself in making drawings for architects and contributing sketches to illustrated papers. In conjunction with Mr. N. H. J. Westlake, F.S.A., he issued by subscription a facsimile of the very rare fourteenth-century MS. Book of Hours in the British Museum, known as Queen Mary's Psalter, his part in which was acknowledged by the late W. Burges to have been executed with rare skill and fidelity.

The late Secretary R.I.B.A.

At the Annual General Meeting of the York Architectural Society, held on the 27th ult., special reference was made to the death of Mr. William H. White, and in a sympathetic letter from the Hon. Secretary, Mr. A. B. Burleigh, the Council has been asked to convey through the JOURNAL to friends and relatives of the deceased the unanimous expression of sympathy passed by the Society on the occasion. Similar letters of condolence have been received from the Liverpool Society, from the Devon and Exeter Society, and from other non-Metropolitan Bodies allied to the Institute. In all cases tribute is paid to the varied talents and accomplishments of the deceased, and eloquent testimony borne to his labours, not only for the Institute with which he had been so long and actively connected, but also for the Allied Societies, which owe him much for his fostering care and interest.

Additions to the Library.

Modern Farm Buildings: their Construction and Arrangement, the second and revised edition of a thoroughly practical and useful handbook by Mr. A. Dudley Clarke, has been received from the publisher [London: B. T. Batsford]. It is a testimony to the completeness of Mr. Clarke's practical knowledge of his subject that his work, which is frequently asked for by students and others, has been adopted by the Council of the Surveyors' Institution as one of the text-books for the Institution examinations. Mr. Clarke goes further than his title indicates; apart from his treatment of the planning and erection of new homesteads, he devotes some attention to the remodelling of types of existing farms so as to meet with modern requirements. The object of the work is primarily utilitarian, and it is a timely contribution to the literature of a subject on which authorities had become a little out of date. It contains numerous plans, besides illustrations in the text.

A couple of brief articles, on "Linear Perspective," which Mr. G. A. T. Middleton contributed to the American quarterly, the *Architectural Record*, have been published, with seventeen diagram illustrations by Mr. Batsford, from whom a copy has been received. Mr. Middleton has divided his subject into two sections—"Elementary Principles" and "The Representation of Shadows and Reflections."

Mr. T. L. Watson's Paper, *Glasgow Cathedral: a Contribution to the History of the Structure*, read before the Architectural Section of the Philosophical Society of Glasgow, has been received from the author. Another pamphlet presented by its authors, W. J. Dibdin and R. Grimwood, through Mr. John Hebb, is *The Analysis of Mortar*, a Paper read at the Summer Meeting of the Society of Public Analysts, and published in the *Analyst* of last August.

Copies of the December number of the *Architectural Record* have been received both from the editor and Mr. Barr Ferree, containing the eighth instalment of Mr. Ferree's series of articles on "French Cathedrals." The present article is devoted to S. Trophime, Arles. Mr. Banister F. Fletcher contributes to the same number his second article on "The Smaller Houses of the English Suburbs and Provinces," and Mr. G. A. T. Middleton writes on the "Early Renaissance in France." An interesting contribution to the number is "Perspective Illusions in Mediæval Italian Churches," by Mr. Wm. H. Goodyear, who seeks to establish a conclusion, based on extensive examinations, regarding optical effects attempted by Mediæval builders.

The third quarterly part for the current year of the *Journal* of the Royal Society of Antiquaries of Ireland (vol. vi.) contains a Paper by Mr. R. A. S. MacAlister on "The Antiquities of Ardoileán, Co. Galway," with six illustrations, and a note on the "Ancient Stained Glass Windows of St. Canice's Cathedral, Kilkenny," by Michael J. C. Buckley, besides other matter, and fully illustrated accounts of the various excursions made by the

Society. Mr. E. Appleton contributes "Notes on Torre Abbey," and the incumbent of All Saints', Kenton, an account of his church, an interesting example of Perpendicular work, to the *Transactions* of the Exeter Diocesan Architectural and Archæological Society (vol. i. part 2).

NOTES, QUERIES, AND REPLIES.

Election of Fellows [pp. 20, 22].

From HARRY SIRR [*A.*]—

In the issue of the 5th November it is pointed out by Mr. Thomas B. Whinney that, by reason of the few advantages Fellows (who pay an additional two guineas a year) possess over Associates, there is a great possibility that an Associate may be thoroughly satisfied with his position as such; and he fears "this evil" arises from the great mistake of giving Associates too much voting power. I venture to question whether, if this satisfaction is felt by an Associate, it is to be lightly held to be an evil. It has been said that the present condition of affairs is serious, and demands strong reforms. It is, therefore, worth while considering whether the inveterate and unsatisfactory classification of professional members should be continued. So far as general observation goes, the public are not impressed when F.R.I.B.A. is substituted for A.R.I.B.A.—nor is it desirable that the Institute should be the guarantor of a man's practice. If there were but one class of professional members, the abolition of the election to Fellowship, the whole business of which appears to be so distasteful, would be accomplished. The Register of Students and Probationers, of course, would remain. Then a roll of honour might well be formed, membership of which would be *conferred* as a distinction.

York Gate, Buckingham Street.

From JOHN HEBB [*F.*]—

The design of this structure has been commonly ascribed to Inigo Jones; but some writers, the late Mr. Wyatt Papworth among the number, are inclined to believe that it was designed, as well as carried out, by Nicholas Stone, a mason, who, with his son, who succeeded him in business, had a yard at the rear of the houses on the south side of Long Acre. Stone's principal business was the making of monuments, of which he executed a considerable number; but it would appear that he occasionally acted as architect, and some persons consider that the design of the Water Gate in the Embankment Gardens was not beyond his capacity. The only documentary evidence in support of the contention that the Gate was designed by Stone is a MS. account-book, formerly belonging to Stone, with notes by his son-in-law, purchased by Sir John Soane at the Strawberry Hill sale, and now in the Soane Museum. The MS. states that the Gate was designed and built by Stone. It is possible that Stone made the detailed drawings of the Gate; but there are sketches of the design among the Inigo Jones drawings belonging to the Duke of Devonshire, and it seems more probable that Jones designed the Gate, that Stone carried it out, and for that purpose made the detailed drawings, which led Stokes (Stone's son-in-law) to assume that Stone made the original design. There is no resemblance between this Gate and other works attributed to Nicholas Stone, but there is considerable likeness to other designs which are known to be by Inigo Jones. The passage from Nicholas Stone's account book in which the design of the Gate is attributed by Stokes to Stone is as follows:—

> The Water Gate att Yorke House hee desined and built and ye Right hand Lion hee did fronting ye Thames. Mr. Kearns, a Jarman (i.e. a kinsman) by mar'ing his Sister, did ye Shee Lion.

Recent Decisions as to Drains and Sewers.

A recent issue of the *Law Journal* states that the House of Lords are to be appealed to for a final solution of the drain or sewer question. The existing statutes are ridiculously defective and inadequate, and their draughtsmen seem to have had a very insufficient insight into the nature of the problems with which their bills had to deal. Almost weekly some illustration of this arises. On 31st October, in *Appleyard* v. *The Vestry of Lambeth*, Mr. Justice Hawkins had before him an action in which the plaintiff claimed a declaration that a conduit constructed by his predecessors in title, with the sanction of the Surrey Commissioners of Sewers, a body corresponding to the old Metropolitan Commissioners of Sewers, was a sewer and not a drain. In *Regina* v. *The Mayor &c. of Hastings* (before Mr. Justice Grantham and Mr. Justice Wright on 7th November), the question involved was whether a conduit which was a sewer within the Public Health Act 1875 had been turned into a drain by the Amendment Act of 1890, or the Hastings Corporation Act of 1885. It is difficult to appreciate the decision, but it apparently amounts to this: that in such cases the local authority must repair under the Act of 1875, but may, in cases within section 19 of the Act of 1890, recover the expenses from the owner when they have taken action after complaint of nuisance duly made. *The St. Martin's Vestry* v. *Ward* (decided on 14th November by Lord Esher, M.R., Lord Justice Lopes, and Lord Justice Rigby) deals with another crux—the meaning and effect of sections 69, 73, of the Metropolis Management Act of 1855. The result of the case seems to be that where a house drain is insufficient, the local authority can under section 73 compel the owner to put it right; but that where a new system of sewerage

is laid down under section 69, the authority cannot charge the owner even of an insufficient drain draining into an existing sewer with the cost of a new and efficient drain into the new sewer.

MINUTES. IV.

At the Fourth General Meeting (Ordinary) of the Session, held Monday, 14th December 1896, at 8 p.m., Professor Aitchison, A.R.A., *President*, in the Chair, with 17 Fellows (including 5 members of the Council), 21 Associates, 3 Hon. Associates, and several visitors, the Minutes of the Meeting held 30th November 1896 [p. 72] were taken as read and signed as correct.

The following Associates, attending for the first time since their election, were formally admitted and signed the Register—namely, James Hewitson Shaw and Ernest Robert Danford.

The Hon. Secretary announced that John Mossop, who by virtue of By-law 20 had ceased to be a member in 1891, had been reinstated an Associate by the Council in compliance with the same By-law.

The Hon. Secretary further announced that by a Resolution of the Council, pursuant to By-law 20, the following defaulters had ceased to be members of the Royal Institute—namely, Frederick John Kingsley Brackenbury Oliphant [*A.*] and Walter Albert Williams [*A.*].

The following candidates for membership, found by the Council to be eligible and qualified according to the Charter and By-laws, were recommended by the Council for election, namely:—As FELLOW, Alfred Baskett Pinckney [*A.*], M.A.Cantab. Worcester; As ASSOCIATES. Harry James Gee Smith [*Qualified* 1896], Philip Appleby Robson [*Probationer* 1889, *Qualified* 1896], and Hubert William Walker [*Qualified* 1894].

A REPORT ON THE SECOND SERIES OF BRICKWORK TESTS carried out under the direction of the Science Standing Committee was read by Mr. William C. Street [*F.*], and a general description of the experiments given by Mr. Max. Clarke [*A.*] with the aid of photographic views shown by the lantern. Professor Unwin [*H.A.*], F.R.S., having briefly explained Appendices I., II., and III., attached to the Report, and given an account of his own independent researches on the subject of THE INFLUENCE OF FORM ON THE RESISTANCE TO CRUSHING [p. 101], a discussion ensued, at the conclusion of which a cordial vote of thanks was passed to Sir William Arrol, Professor Unwin, and Mr. H. F. Donaldson [*H.A.*], M.Inst.C.E., for the valuable aid they had afforded the Committee, and to the members of the Sub-Committee who had directed the experiments and reported and tabulated the results.

The proceedings then terminated, and the Meeting separated at 10.15 P.M.

LEGAL.

Professional Responsibilities.

BAZZONI *v.* NOTLEY.

In this case Mrs. Bazzoni, a widow, sued Mr. R. P. Notley, architect and surveyor, to recover damages for alleged misrepresentations with respect to the drainage of a house. Defendant denied the misrepresentations. Mr. Lawson Walton, Q.C., and Mr. E. Morten appeared for the plaintiff; while Mr. Kemp, Q.C., and Mr. Bremner represented the defendant.

The plaintiff stated that in January 1895 she saw the defendant with a view to taking a house known as Warwick Lodge, Clapham-park. She asked the defendant in what condition the drains of the house were, and he replied that he had within the last few years put in new drains, and that they were in every way satisfactory. She pointed out that there was no air-shaft to the main drain, and the defendant replied that it was not necessary, having regard to the system of drainage which had been adopted. Relying upon that statement, she took the house under an agreement. The agreement contained a covenant that in the event of the drains being condemned or going wrong during the tenancy the landlord, and not the tenant, should execute the repairs. In March two of her servants became ill with sore throats, and had to leave her service. Subsequently she, her daughters, and a sister became unwell, and it was then suspected that the illness was attributable to the drains being defective. A builder was called in, and he suggested alterations, which the defendant had done. The bad smells continued, however, and the sanitary inspector, who was sent for, ordered further alterations to be made. There was a delay in the execution of the work, and she was obliged to send two of her daughters away to school. In consequence of the state of the drains she had to pay doctors' fees, &c., to the extent of £75. Witnesses were called to prove that the illness of plaintiff, her daughters, and servants was due to the presence of sewer gas.

The defendant stated that he was an architect and surveyor of thirty-five years' experience, and had had a great deal of sanitary work. In 1891 he had the drains of the house reconstructed. The system adopted was that of Mr. Norman Shaw, and it gave every satisfaction. In the early part of 1893 he received notice from the sanitary inspector requiring him to carry up the ante-syphon pipes. When plaintiff saw him in January 1895, he told her that the drains had been reconstructed in 1891, and that to the best of his belief they were all right. The first time the plaintiff complained of the drains was in August, and not April, and at that time he was away on his holidays. He went down to the house in September, and saw the plaintiff's builder, who suggested that a ventilating pipe should be carried up to the top of the house. He convinced the builder that that pipe was not necessary. There was nothing insanitary in the premises at the time. In October he received a notice from the sanitary inspector to remove the intercept or traps; but that was not a proper thing to do, as the object of the traps was to prevent sewer gas getting into the house. Eventually he did more than the sanitary inspector had ordered, though in his judgment there was no necessity for the requirements of that official. The state of the drains was due, not to any defect in the drains, but to the fact that they had not been properly flushed and the traps kept clear. Shortly after the plaintiff had taken possession of the house there was a sharp frost and very little water.

Experts were called to prove that if the drains at the house in question had been properly flushed and the traps kept clear no sewer gas would have got into the house. The house was drained by the Norman Shaw system, which was in use at the Royal Academy, Haggerston Castle, Berwick, Scotland Yard, Queen's Gate, &c. The jury found a verdict for the plaintiff, and assessed the damages at £40. Judgment accordingly, with costs.

Subdivision of Warehouses.

CROW *v.* KEARLEY & TONGE.

At Worship Street Police Court, on the 26th November, Mr. Cluer made an order affirming a "notice of objection" served under section 150 of the London Building Act 1894 by Mr. Arthur Crow, District Surveyor, upon Messrs. Kearley & Tonge, the owners of warehouses in Durward Street, Whitechapel. The notice in question required that a certain additional warehouse, which is about to be erected, of a greater extent than 250,000 cubic feet, should be divided by party-walls in such a manner that no division thereof should extend to more than 250,000 cubic feet in accordance with the provisions of sec. 75 of the Act.

In appealing against this requisition of the District Surveyor, Mr. J. P. Grair, on behalf of the owners, con-

tended that sec. 74 entitled them to adopt fireproof ceilings or floors in lieu of party-walls. He quoted the section as follows:—"Every building shall be separated either by an external or by a party-wall or other proper party-structure from the adjoining building," and pointed out that by definition 20 a horizontal floor was included in the term "party-structure." He said that a party-wall, by sec. 5 (16), was defined as being "a wall forming part of a building and used or constructed to be used for separation of adjoining buildings belonging to different owners or occupied or constructed or adapted to be occupied by different persons," and consequently did not apply to the present case, as the buildings in question would be owned and occupied entirely by his clients. He then called Mr. Wm. Eve, architect, who produced the plans of the building, and described the method of construction proposed to be adopted. He stated that the buildings would be entirely separated from each other by fireproof floors, the only means of communication between them being an approach on each floor from a staircase which was external to and separate from the buildings themselves. He suggested for the learned magistrate's consideration that they would thus form three separate buildings, each having a separate entrance from without. He thought it right, however, to say that there would be lifts running up through the buildings, but shut off by 9-inch walls and iron doors.

In cross-examination by Mr. F. F. Daldy, who appeared for Mr. Crow, Mr. Eve said that the floors would be of heavy construction, being calculated to carry about 7 cwt. to the foot, and that these would be carried by cast-iron supports. Asked whether in the event of a serious fire breaking out in one of the storeys the cast-iron supports would not be liable to crack, and thus cause the floors to fall in, he said they would substitute wrought iron if the District Surveyor preferred it.

Mr. Daldy urged that although the term "party-structure" in sec. 74 included a horizontal floor as well as a party-wall, sec. 75 required a "party-wall" and not a "party-structure," and his learned friend could not get out of his liability to provide a party-wall under sec. 75 by falling back on the party-structure provision of sec. 74. He quoted the case of *Holland & Hannen* v. *Wallen*, which decided that a horizontal floor was not a party-wall.

Mr. Grain, in reply, contended that section 75 was merely inserted in the Act in order to amend the corresponding section of the Act of 1855, which limited the size of a warehouse to 216,000 cubic feet, and section 74 of the new Act being entirely fresh legislation his clients were entitled to take advantage of it.

Mr. Cluer, who had taken time to consider his judgment, said he was unable to agree with Mr. Grain's contention that ceilings were to be treated as "party-walls." The building was, he decided, one building, and as such had to be divided by party-walls. If the statute had meant that you might build a large building, and each division of it—each floor, that is—might be 250,000 cubic feet, it would have said, "unless it be divided by party-structures," making it clear that each floor might then hold 250,000 cubic feet. He could not read into section 75 of the Act the word "structure" instead of "party-wall."

In affirming Mr. Crow's notice of objection, he allowed seven guineas costs.

It being suggested that a case on a point of law would be asked for, Mr. Cluer said he should be very glad for the High Court to decide whether a ceiling was a party-wall.

Arbitration in reference to Dangerous Structures.

BERNSTEIN *v.* THE LONDON COUNTY COUNCIL.

A case decided by Mr. Cluer at Worship Street on the 26th November disclosed another defect in the wording of the London Building Act 1894.

By section 107, if the owner of a structure certified to be dangerous disputes the necessity of any of the requisitions of the District Surveyor as embodied in the statutory notice required to be served in such cases by the London County Council, "he may by notice in writing to the Council within seven days from the service of the notice upon himself require that the subject shall be referred to arbitration."

The section further provides that "in case the owner require arbitration he may at the time of giving such notice appoint an independent surveyor to report on the condition of the structure in conjunction with the district surveyor within seven days of the receipt by the Council of the notice of appointment of the owner's surveyor and all questions of fact or matters in dispute which cannot be agreed between the owner's surveyor and the district surveyor shall be referred for final decision to a third surveyor who shall (before the owner's surveyor and the district surveyor enter upon the discussion of the question in dispute) have been appointed to act as arbitrator by such two surveyors or in the event of their disagreeing by a petty sessional court on the application of either of them:

"Such arbitrator shall make his award within fourteen days."

It appeared that the District Surveyor (Mr. Crow) had certified that two houses, known as Nos. 23 and 25, Brushfield Street, Spitalfields, were in a dangerous condition, and required certain portions of the structure to be taken down. The owner of No. 25 gave notice of arbitration, the notice being received by the Council on the 23rd October, and at the same time he appointed Mr. H. H. Collins as his surveyor. The two surveyors then agreed on a third surveyor, Mr. E. A. Gruning, to act as arbitrator. So far matters had proceeded within the seven days' limit, but then a hitch occurred. The District Surveyor suggested that a meeting of the two surveyors should take place at the premises on the 29th; but Mr. Collins could not confirm this, owing to another engagement for that day, and named the 3rd November. The District Surveyor pointed out that this would not be within the seven days' limit, but on Mr. Collins' assurance that the time limit did not apply to such meeting he agreed to meet on that day. Owing to his being subpœnaed in a High Court case, Mr. Collins was again unable to attend. The District Surveyor then declined to make any further appointment under the Arbitration Section, but offered to meet Mr. Collins on the 6th November to try and arrange what should be done to secure the building, but on the understanding that the claim to arbitration should be abandoned. This Mr. Collins would not agree to, and the owner having failed to comply with the Notice of the London County Council the matter was brought before the magistrate.

Mr. J. W. Godfrey, on behalf of the London County Council, pointed out that the intention of the Act, which he contended was borne out by section 107, was that the owner should have seven days in which to consult his surveyor and ask for arbitration; that then a further period of seven days was allowed for the two surveyors to draw up their report; and that in the event of disagreement a final period of fourteen days was allowed for the arbitrator to make his award—making in all twenty-eight days—which appeared a reasonable time in which to complete the arbitration.

Messrs. Wild & Wild appeared for the owner, and contended that the seven days' limit did not apply to the meeting, or, that if it did, it had been waived by the District Surveyor, and no right remained to rely on it afterwards. Further, it was contended that the Act nowhere specified a beginning for the fourteen days within which the arbitrator was to make his award.

Mr. Cluer said that the Act left it to the parties to go to an arbitrator to get a settlement within a reasonable time. He decided that the District Surveyor, having rightly agreed to meet the owner's surveyor after the seven days' limit, was wrong in refusing to meet him at a later date. He dismissed the summons, and ordered the London County Council to pay seven guineas costs.